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Effective measurement of the economy in the emerging digital age[1]

Francis Gross, Antonio Colangelo and Florian Schuster,
European Central Bank

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Effective measurement of the economy in the emerging digital age[1]

Antonio Colangelo, Francis Gross and Florian Schuster

Abstract

Since the Crisis, banks' internal data have massively expanded to meet regulators' growing demands. Banks and public institutions are changing profoundly as digitalisation and technological change affect their internal processes and their interaction with other market participants. The financial sector's new mass data is messy, rarely enabling straight-through processing. Many legacy practices, fragmented across countries, companies and generations of systems, are obsolete. Control functions have fallen way behind the speed, scale and complexity of market action and progress is too slow to catch up as technology keeps accelerating. A necessary condition for improvement is a radical acceleration of standardisation activities across countries. Effective standardisation demands strict discipline that only law and infrastructure can provide. Central banks, at the centre of the new data world, could catalyse standardisation by devising a vision and designing conceptual solutions. Integrating banks' external reporting requirements through a single dictionary and organising reporting in a single data architecture are immediately feasible steps.

Keywords: Digitalisation, identifiers, standards, central bank statistics, Integrated Reporting Framework (IReF), Banks' Integrated Reporting Dictionary (BIRD)

JEL classification: G21, E50, C81, C82, L15

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1. Introduction

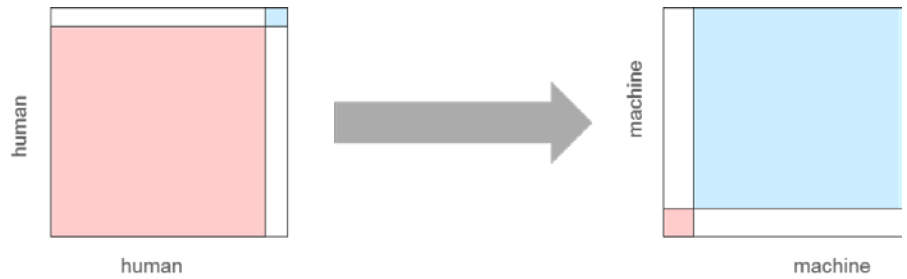
This paper provides a conceptual framework for the rising Data Problem and makes the case for a radical acceleration of standardisation activities on a systemic scale, from identifiers to, ultimately, standards for the representation of contracts and their states along their lifetime. As a health warning, it should be noted that the authors take a holistic, conceptual approach, which is somewhat unusual for this type of paper. Sections 2 and 3 are written combining the perspectives of the scientist and the designer. The scientist accepts the facts observed and thinks from there. The designer explores conceptual solutions, which would remain out of reach if exploration was conducted within the narrow bounds of immediate feasibility constraints. Section 4 reviews two Eurosystem initiatives relevant to the topic, BIRD and IReF, while Section 5 concludes proposing a way forward towards sustainable and effective measurement of the economy in the digital age.

2. The Data Problem

What is data? Data are symbols generated independently by millions of sources across the world. The Data Problem arises when data is separated from their source and there is no more guarantee that they mean to a reader what they were created to represent by their author and no way to clarify the meaning by asking. The Data Problem grows when data from ever more sources is collected, pooled and processed by machines and people.

The digital age sees rapidly increasing connectivity, globally. Machines and applications exchange data, in principle without requiring human-to-human or human-to-computer interaction. Networks see speed and capacity explode, next with 5G; billions of connected objects form the emerging 'internet-of-things'. Artificial Intelligence, though immature, is adopted on a grand scale, driven by competition.

Figure 1. The interface has shifted



The Data Problem is not new, but statisticians have always considered that human intervention could control it – e.g. by providing definitions and manuals for reporting agents explaining how to link source data to reporting requirements, or by adjusting and reconciling the input received to ensure harmonised output. Likewise, users in all sectors relied on "fixes", "data wrangling", to cope. In a simple, slow, human-to-human world, the paradigm may have worked. However, the complexity of the world we are living in keeps increasing and technology has shifted the human-machine interface quite radically. Automation, data volumes, global scale and speed now overwhelm human capacity for good.

Technology changes the financial industry in myriads of ways, as new business models are tested all over the world and FinTechs develop digital ways of providing banking services. For example, digitalising the lending application process using "big data"[2] can accelerate to nearly real-time the 'time-to-decision' of a loan, currently between three and five weeks.[3] Technology is also changing the very structure of the financial industry, with the emergence of new service providers (e.g. Ant in China), large cloud providers, "open banking", etc. and the emergence of entirely new concepts such as digital currencies.

Alongside those shifts, technology has also driven the specifications for effective measurement in the system, the job of Statisticians, to a whole new level. Indeed, if effective measurement means to provide timely information at the scale of the event measured, and if the most dangerous events can be global, real-time, at least some measurement needs to work global, real-time. Given that such events can arise suddenly and unfold in unforeseeable ways, the measurement system must always stand ready and be nimble adjusting to surprising events.

Global, real-time, nimble, always on: those specifications leave little choice but to build a measurement chain connecting operations to analytical systems, straight-through, fully automated, on a global scale. As one consequence, operational data must serve such measurement directly, as there will be no time for transformation and reporting other than fully automated. In other terms, the future of at least some reporting is "no-reporting": regulators will access the data they need, online and in real time. To that end, operational data must ultimately be subjected to "hard" [4] standardisation, globally.

Whereas these broad specifications can seem extreme, they espouse quite well the trends to cloud and to the large-scale operational systems of internet companies, which makes them less outlandish, especially considering the magnitude and speed of change we witness. The financial services industry of tomorrow will be very different from today's indeed – many industries have gone the same way and improved.

Issues related to data protection are left out of this consideration. The digital age will see evolutions in the societal, legal and technical fields. Some of these can be guided by policy for the purpose of systemic stability. This paper examines the technical constraints and specifications of effective measurement in the context of technology and the use made of it. Societal processes will then discover a hopefully coherent balance between technical progress, systemic stability and privacy. For instance, one could imagine a conceptual architecture with operational systems and their data running on a "global cloud" – single or federated – where all parties would have access to their own contractual footprint whereas authorities could interrogate the entire system, with regulated access only to specific data.

[2] See, for instance, Daley (2020).

[3] See, for instance, Chappel et al (2018).

[4] A standard is defined here as "hard" when the implementation leaves room for only one interpretation. The LEI is an example of a "hard" standard as the unique valid data set is stored in an infrastructure that all users can access. As opposed to a "soft" standard, which is essentially a publication by ISO, open for interpretation by any user, potentially leading to diverse implementations across the population.

The specifications for effective regulation will change as well. Effective regulation will have to work at the scale of the system that is relevant for the events that could endanger stability. For many events, that relevant system is now global, so that regulation restricted to the national level miss the relevant system by an increasingly wider margin. The global financial system is becoming ever more complex and tightly coupled, the hallmarks of a vulnerable system.[5] That raises another deep challenge: the need to reconcile the local nature of human political organisation that carries regulatory institutions with the global nature of technology-fuelled markets.

That reconciliation must be designed to accommodate the full diversity of sovereign choices and rules in the global, standardised technical data infrastructures, public goods that serve all parties in all sectors. An example of such design can be found in the Global LEI System where the identity of any legal entity is given a globally standardised representation without prejudice to the local identifiers and legal form, the latter being identified in the Entity Legal Form (ELF) Standard[6].

A solution to that challenge might be easier to discover and start in the more technical functions supporting market regulation, for instance measurement. It could begin with the technical data interface between markets (global) and authorities (local). Building global data standards and the related data infrastructures that make them into "hard" standards – as the LEI – could offer a good initial laboratory for designing technical, organisational and legal solutions at the requisite scale.

Ultimately, regulation will need to adjust to the speed (real-time) and scale (global) of the system relevant to regulation and to emerging industry structures that blur once solid sectoral boundaries. That might require designing new, digital-age-worthy mandates and building institutions to serve them. A start has been made in the EU with the creation after the Crisis of several pan-European institutions.

If statisticians were to embrace the specifications for measurement presented above and take up the challenge of reforming the legacy of the statistical world, a shift in strategic outlook would serve them well in achieving success. Better measuring the financial system will require intervention to make the financial system more measurable under the conditions of the digital age as it will be. Such an undertaking requires a strategic horizon of thirty, forty years – the time to conceive and build infrastructure plus a decent span of useful life – and a global scale. To achieve that statisticians would need to design a grand project and durably mobilise society's leaders. A project plan would have to include designing (i) a conceptual "endgame"-architecture based on broad "Tech-2050" scenarios and on invariants (e.g. sovereign law, legal entities, contracts), (ii) migration paths exploiting current trends and market forces, as well as (iii) feasible initial steps with transformational power (easy to do, benefits to all, inspiration for more). A few starts are underway, such as the Global LEI System, dictionaries (BIRD), new data collection strategies (the ECB's IReF, BoE's strategy), large scale, near-time granular data collections (EMIR, IReF) and large new granular databases (the ECB's Centralised Securities Database). These, for some of them large, investments are laudable, but they are insufficient, and their progress

[5] See Perrow (1999) – a system is said to be "tightly coupled" when it has components offering little slack, i.e. allowing a shock to propagate instantly throughout the system. Complexity makes for unpredictability of the system-wide impact of a shock.

[6] ISO 20275.

remains too slow and they could benefit from a comprehensive systemic target architecture.

Statisticians find themselves caught in a double pincer: (i) whereas digital-age specifications for good measurement seem unavoidable and put extreme new demands on data quality, the Data Problem keeps growing, taking data quality further away from those demands and (ii) whereas the speed of tech-driven change keeps increasing, making change more urgent, statistics, already slow to move within its old paradigm, will slow down further as it needs to accept and move to a new paradigm and to align globally. That double pincer makes the Data Problem central to sustaining Statistics' effectiveness in the digital age. It also makes action an urgent necessity.

Action might best begin with broad dialogue among all parties, across all sectors, exploring the Data Problem, and starting the conceptual design of solutions, migration paths and initial steps. Ideas developed through such a dialogue would both be better and strengthen acceptance of the resulting public goods and their legal mandating. Dialogue could also help in unsettling conservatism by shifting the perception from regulation as a growing burden to regulation as a way of designing together a frame of rules that will make the game sustainable for all in the digital age. Finally, that could contribute to shifting the financial impact from a perception of "cost" to one of "investment", business decisions to improve one's competitive position and generate superior returns. This has been done in many areas of the economy that have improved as a result.

Finally, the Data Problem has similarity with Climate Change: it affects all parties globally, a solution is conceivable yet demands cooperation, and both hold potential for catastrophic failure if left unaddressed. However, the Data Problem is the smaller one; solving it depends on changing behaviour in a smaller community of professionals: the financial industry, regulators and lawmakers. Also, the now strengthening dynamic on Climate Change could be used to solve the Data Problem, if we can show that Climate solutions require better data, for instance on tracking supply chains.

3. A conceptual framework

The specifications for measurement of finance and the economy in the digital age raise extreme demands that seem impossible to reach with traditional methods. A different concept of the substance we measure could generate new ideas. Other sciences have demonstrated the breakthrough power of new concepts, new ways of seeing reality, e.g. the periodic table gave us a different view on matter and enabled modern chemistry and materials science.

Contrary to matter, the economy and finance are immaterial substances, inaccessible to our natural senses. Whereas it is easy to agree about fact with material objects, this is less evident with immaterial objects. However, some immaterial objects can be treated as facts, namely objects defined by law, such as the identity of a person or a legal entity.

A basic challenge of measurement lies in the representation of objects. It is easier with objects that are facts that, by definition, give the possibility of a unique representation, accepted by all, globally. For instance, in the immaterial world, the

name of a person or a legal entity will be recognised by all citizens of all sovereigns who recognise the sovereign that gave that person or that entity her identity. Therefore, the name of a person or an entity, once enacted by a single sovereign, becomes a fact for all citizens, globally. The same logic applies very largely to other categories of immaterial objects made facts by law, as for instance to contract terms.

This opens the possibility of a simple concept for the substance of economy. If we consider contracts and parties as basic factual elements of the economy, the substance of the economy could be conceived as a network of contracts that connect a global population of parties. There is much more to the economy, of course, but that network could be used as the skeleton that helps to organise all the rest of it.

For one, that concept reconciles the divide between a global economy and local societal systems; indeed, each contract and each party of that global system is anchored in at least one local, legal system. A national economy is a sub-system of the entire system.

Measurement would look at that network of contracts as a graph, a notion close to large-scale computing and with strong underlying mathematical theory. Identifying the nodes and edges of that graph then becomes the evident starting point of any measurement.

Many concepts known to economists, statisticians and regulators (including those referenced in BIRD) can be built from that graph: the contractual footprint of a legal entity (resp. group) represents the entire business of that entity (resp. group). The contractual footprint of all parties attached to a sovereign, e.g. by a passport, a legal form, a residency, represents that country's economy with contracts within the population of parties providing national accounts and contracts to the outside throwing up balance of payment. A party's exposure to an event can be represented as a set of contract chains or contract networks connecting the event to the party, along which a shock can propagate. A relationship among entities (e.g. "control") can be defined as a constellation of contracts (direct or chains). A group structure is determined by the choice of relationships (majority ownership or else) used to define it, hence it can vary with the observer as we know it today. That approach suggests the possibility of deriving macro concepts from micro-data organised around the contracts and parties that form the graph.

Proper organisation of the data and of the analytical systems could enable large-scale, real-time measurement, nimble to adjust to new demands and new situations. Adding data elements to the skeleton of factual data could be organised quickly and cheaply through online input by all relevant parties on elements pertaining to them, a gain over current ad hoc data collections. Stress tests could be envisaged as frequent, quasi-automated exercises flexible enough to address many questions and test diverse scenarios.

Ultimately one could see measurement as permanent "live video" of the system, playing the role of artificial senses for a reality our natural senses do not perceive.

Different users would be able to shape their own measurement as they wish, knowing that their results would be consistent with others' measurement, as they come from the same representations of facts.

Reassuringly, as in engineering, the legacy techniques would perform very well for most applications. In engineering, for instance, only cutting-edge designs require the use of quantum physics (e.g. chip design), whereas Newtonian physics is largely sufficient for most machines and building tasks. In Statistics, cutting-edge

measurement would be needed for serving financial stability, especially in technology-intensive fields, whereas most other statistics could continue as so far. However, also classical statistics would benefit from new infrastructure to become more efficient and see quality improve, for instance through easier provision of breakdowns and shorter frequency. Creativity of statisticians would be given new spaces and potentially new resources, freed through efficiency gains.

Implementing that concept would demand as a first step the creation of a global, public-good data infrastructure that would hold globally standardised identification of all parties and contracts, real-time accurate. For legal entities, that could be achieved quite simply by connecting official registers to the Global Legal Entity Identifier System, which could be the kernel of such an infrastructure. That, however, would require relevant authorities, usually outside the remit of central banks and statistical offices, to move in support.

A next step would be to represent all contracts in a standardised, mathematically rigorous algorithmic language, whereby such a language would represent contracts in all their diversity stemming from local legislation and practices. Whereas a more distant goal, this is conceptually possible, as all contracts can be represented as algorithms (who does what for whom, when and under what circumstances). A start could be imagined in applying that principle to simpler contracts (e.g. loans) in a single jurisdiction (e.g. the EU), serving measurement (e.g. a future AnaCredit 2.0) as well as business operations. The Algorithmic Contract Type Unified Standard (ACTUS) standard could offer a starting point here[7].

As ulterior conceptual steps, the data infrastructure could be enriched with a ledger of assets (identifiers and representations) referenced in contracts as well as events driving contracts (e.g. instalment dates in a loan contract).

Ultimately, a powerful new analytical tool might emerge. Contemplating the real world, the analyst would develop scenarios of events around a theme (e.g. drop in house prices –> loan failures –> impact on securities, derivatives –> etc.). Feeding such scenarios of events into the population of contracts, the graph would rapidly reveal the potential "mechanical" impact of the events. This would guide policy makers who could then also test and calibrate policy ideas using the same system.

There is a long way to go, of course. Progress will require bold thinking, overcoming the high hurdle of our current paradigm and constraints, but the facts we can observe are telling us that there might be no alternative and that time is pressing. We face a fundamental choice: either stumbling into the future, step by step as budgets allow, or designing our steps to form an organised migration path, guided by a conceptual design frame that fulfils the specifications of effective measurement, fit for the digital age.

Several promising initiatives are under way, also in the Eurosystem. Two of them, BIRD and IReF are presented here.

[7] ACTUS offers algorithmic representation of so far over 30 contract types that cover most known financial contracts.

4. The Eurosystem initiatives

Over time, and especially after the Crisis of 2007-2008, regulators all over the world have vastly expanded their data demands, without investing in solutions that would minimise the impact on reporting agents. Datasets collected for regulatory purposes have traditionally been defined in isolation, without coordination across the institutions. Europe was no exception, and legacy systems played a vicious role. For instance, the ECB has traditionally set out statistical regulations for banks in silos and leaving discretion to NCBs to collect the required data as part of the statistical reporting framework they have established under their own responsibility. De facto, a cross-border bank, in order to fulfil the same set of statistical requirements, must deal with heterogeneous national systems that feature different models and dictionaries, complex transmission schedules and processes, etc.[8]

Against this background, the Eurosystem has developed a vision which primarily aims at reducing reporting burden by standardising and integrating statistical data reporting through two strictly connected initiatives.[9] The Integrated Reporting Framework (IReF) integrates banks' statistical reporting requirements into a unique framework that would be directly applicable to euro area banks, without any translation into national collection frameworks. In order to effectively integrate the existing requirements, the IReF will encompass a set of requirements with different levels of granularity that will consolidate the existing reporting lines across countries into a unique framework and avoid any duplication of the requirements. The reporting will be defined through a standardised data model and the same reporting schedules will apply across the euro area.[10] The Banks' Integrated Reporting Dictionary (BIRD) is a joint initiative with the banking industry aimed to help reporting agents efficiently organise information stored in their internal systems and fulfil their reporting requirements, going beyond statistical requirements covered in the IReF and also including prudential and resolution requirements of banks. The BIRD defines the transformation rules to be applied to banks' input data in order to transmit data to the authorities. Figure 2 shows how BIRD and IReF will affect the reporting of banks. By applying BIRD, banks are in the position to generate reporting requirements from a single redundancy-free defined input layer.

The IReF and the BIRD are being developed closely to each other and will rely on a common data dictionary that will ideally be developed in cooperation with the European Banking Authority following the feasibility study[11]. The common dictionary will ensure the standardisation of the definitions (also with resolution and prudential data), reducing the effort banks would otherwise make interpreting and reconciling instructions formulated in different frameworks. While the BIRD is expected to remain voluntary for the banking industry (at least for the time being), the use of a common

8 See also European Banking Federation (2019).

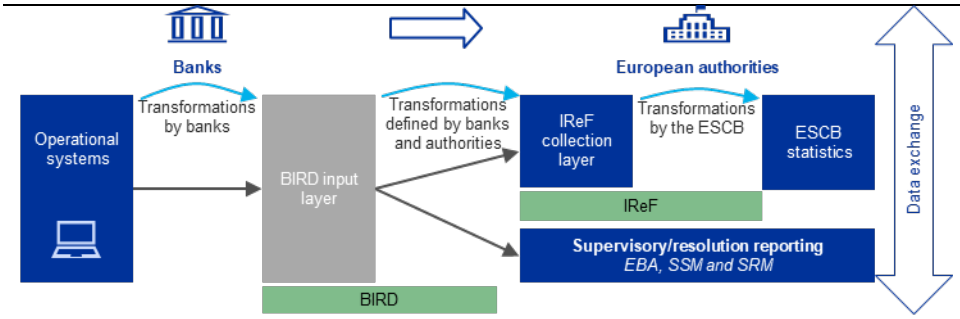
9 These initiatives are part of a broader data integration strategy requested by the European Parliament and Council as well as by the European banking industry; see European Central Bank (2020a).

10 See European Central Bank (2020b).

11 See Article 430c of Regulation (EU) 2019/876 of the European Parliament and of the Council of 20 May 2019 amending Regulation (EU) No 575/2013 as regards the leverage ratio, the net stable funding ratio, requirements for own funds and eligible liabilities, counterparty credit risk, market risk, exposures to central counterparties, exposures to collective investment undertakings, large exposures, reporting and disclosure requirements (OJ L 150, 7.06.2019, p. 1).

dictionary will represent an important incentive for adopting it. At the same time, it should be noted that the existing BIRD modules that have been developed for supporting statistical reporting (e.g. in the context of AnaCredit) only serve as a methodological reference, but cannot be directly applied by reporting agents due to the heterogeneous national implementation of these requirements. With the IReF this circumstance will be rectified and with a homogenous implementation across the euro area the banking industry is expected to benefit significantly.

Figure 2. Eurosystem strategy for collecting data from banks



Notes: EBA stands for European Banking Authority, SSM for Single Supervisory Mechanism and SRM for Single Resolution Mechanism.

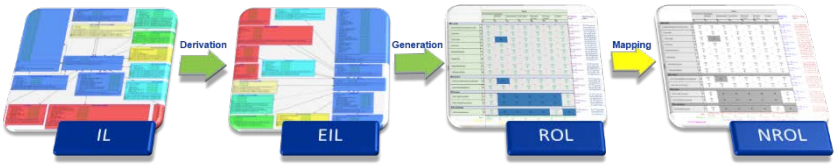
One of the critical success factors for the Eurosystem strategy relates to the way it will address the requirements covered in the national (statistical) collection frameworks of NCBs that do not arise from the existing ECB statistical regulations. The objective is that under the IReF country-specific requirements should be kept to a minimum. However, it is clear that (some) country-specific requirements will continue to exist under the IReF. As explained in the cost-benefit assessment on the IReF[12], the Eurosystem is expecting to develop an extended IReF layer which would model and describe these residual country-specific requirements from a technical perspective. Such an approach would support reporting agents, e.g. by ensuring that overlapping requirements across countries are described in the same way. The common requirements will be covered in the ECB Regulation on the IReF, whereas the country-specific requirements will be legislated for at national level tough technically part of the extended layer.

The IReF and its foreseen extensions will cross-fertilise with the BIRD and result in further advantages for reporting agents. Before exploring these changes, it is necessary however to describe the current BIRD process in more detail, as shown in Figure 3.[13] For the sake of simplicity, the individual components are explained in the order of how they are logically established.

12 See European Central Bank (2020c).

13 Please notice that some BIRD components like the very normalised Logical Data Model (LDM) are not shown in this depiction for the sake of simplification.

Figure 3. BIRD process



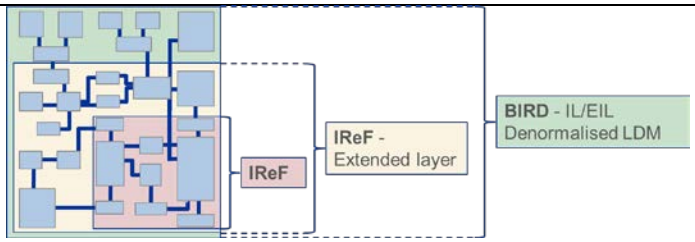
The non-reference output layer (NROL) is the description of reporting requirements based on the original codification system (e.g. EBA DPM). Via (Meta data) Mappings the original codification is translated into the reference codification. The reference output layer (ROL) therefore describes all reporting requirements in one standardised language. This is already advantageous, but the next step is to describe all the various reporting requirements within a redundancy-free data model. These are the input layer (IL) which acts as interface to the banks source system and the enriched input layer (EIL) which comprises the same information as the IL but also concepts (e.g. classification of small and medium-sized enterprises) that can be derived from the input. Formal transformation rules bridge the gap between IL, EIL and the ROL.

Two issues are relevant to explain how the IReF fits into the BIRD process.

- Firstly, the IReF is using the same reference codification system as the BIRD. As a result, the NROL and mappings are irrelevant in this case.
- Secondly, in order to achieve integration via a relational model and be redundancy-free, the IReF features a high degree of granularity and detail.

The IReF is thus moving much closer to the IL/EIL structure in terms of modelling and content than other reporting requirements. For this reason, it makes sense to very much align in terms of the data models both the IReF and the BIRD.

Figure 4. BIRD, IReF and the extended layer



Notes: This depiction provides a conceptual representation, not a physical one.

As shown in Figure 4, the data model of the IReF and its extended layer can be conceptualised as a slice of the BIRD enriched input layer or, depending on the view, the BIRD EIL an extension of the IReF. It is important to emphasise that this alignment is at the level of the data model, meaning that the actual content of the IReF can diverge, for example in terms of level of aggregation.

An alignment has the potential to utilize many synergies. The familiarity with the BIRD model will grow significantly considering that the IReF and its extended layer will form a primary reporting required across the euro area. This can be considered

an important step towards a more automated and on-demand reporting, which will easier materialise through two intermediate phases.

Phase 1: BIRD and IReF in their first configuration do not change the overall fabric of reporting but rather prepare the foundations for future bigger steps. The IReF will require largely 1:1 transformations from the IL/EIL. Other frameworks not included in the IReF (e.g. FINREP) would continue to require more complex transformations from the BIRD IL/EIL. With this solution the banking industry can fulfil all reporting requirements in a consistent way and enabling a reconciliation at the level of the authorities. Based on such positive results, authorities might be more inclined and willing to abandon aggregated (e.g. template) reporting in favour of a more structured and redundancy-free granular reporting.

Phase 2: Aggregated reporting can be phased out over time through an extension of the IReF. It is important to stress that the authors do not imagine a big bang solution but rather a stepwise approach, although guided by an "endgame design concept". Eventually this process could lead to the BIRD input layer becoming the required reporting with only limited aggregated requirements remaining (e.g. for the purpose of requiring reporting agents to remain liable for certain values).

The standardisation envisaged within phase 1 and 2 in conjunction to the development of international standards and infrastructures (e.g. LEI) can lay the foundation of reporting via the digitalisation of contracts and an on-demand reporting or direct access to data from the side of authorities.

5. Conclusions

The Eurosystem initiatives described above represent important steps towards reducing reporting burden while improving its outcomes. Their benefit will increase however if they are integrated into a more comprehensive vision and strategy to accompany ongoing digitalisation. In Figure 2, for instance, reporting agents still need to bridge the BIRD input layer with their operational systems where contracts, parties and other facts remain represented in diverse ways. Hence, standardisation in the representation of the operations underlying financial markets is a necessary condition for fulfilling the digital-age specification of effective measurement.

To achieve true digitalisation, standardisation must first refer to the foundational level of identifying and representing financial contracts, parties and other facts. This will have to take place involving market participants, and possibly leveraging on on-going initiatives. Standardisation will need to be radical to work sustainably; compromises will be counterproductive and voluntary adoption too slow when time is now of the essence. Where rigorous discipline among millions of parties is required, that will likely require legislating the use of standards and public data infrastructures. As noted by Ramsey (2021), standards are the typical example of a public good, that market participants by themselves will not realise although the benefits will outweigh costs for society. Public authorities then need to intervene and catalyse change to achieve the common good. Efforts should first focus on building strong and global identification infrastructure for contracts and parties.

The digitalisation of financial services also opens new possibilities towards the standardisation of the technical representation of financial and other contracts. Many initiatives are on-going to develop standards for specific financial instruments (see

also Bank of England (2021) and BIS (2020)). However, whereas these ongoing initiatives are mostly local, an effective solution, accepted in markets, would need to be far wider, being ideally global and to cover all contract types, as proposed by the ACTUS initiative. Continuing with local, siloed and underfunded initiatives will deliver yet another wave of heterogenous solutions, forming the next generation of messy legacy that will cost more and this time perhaps lead to failure. Coordination across jurisdictions is thus key. The digital transformation that affects all of us offers a unique opportunity to authorities to strengthen their catalytic role by leading the development of a comprehensive vision and the design of a conceptual architecture that would provide a frame in which local initiatives could flourish while forming a coherent system, sustainable in the digital age.

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