Towards Ontological Convergence of Accounting Frameworks

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Abstract
Converging and matching frameworks, standards, and ontologies is crucial for achieving semantic interoperability, integration, and alignment of information across different systems and domains. The corporate reporting domain, like many others, is governed by a complex array of accounting, financial reporting, and sustainability standards. This paper presents a novel approach to addressing the convergence challenge between the IFRS and US GAAP Conceptual Frameworks for Financial Reporting by grounding them in UFO-based upper ontologies. A converged ontology is developed and modeled in OntoUML, with the resulting converged concepts defined and discussed.

Keywords
IFRS, US GAAP, Conceptual Framework, UFO, OntoUML, COFRIS, Convergence

1. Introduction

Converging and matching frameworks, standards, and ontologies is an essential process in achieving semantic interoperability, integration, and alignment of information across different systems and domains. When ontologies are created independently, they may differ in structure, terminology, or granularity, making it necessary to converge them for a unified understanding and use. Converging ontologies is a complex but critical process to achieve semantic consistency, reduce redundancy, and facilitate knowledge sharing and integration. The process includes matching and alignment, merging, conflict resolution, foundational ontology alignment, validation, and documentation [15].

The corporate reporting domain, like many others, is governed by a complex array of accounting, financial reporting, and sustainability standards. These standards are developed by various entities – such as regulatory bodies, professional organizations, and industry groups – at different times and across different jurisdictions, leading to inconsistencies and fragmentation. Most of these standards attempt to ground themselves in some form of Conceptual Framework (CF) to ensure coherence and provide a structured foundation. However, harmonization efforts have emerged to align and converge these frameworks, such as International [1] and U.S. [2], reflecting a growing need for consistency across different reporting systems. As the primary focus of these frameworks is to facilitate standard setting, one of the immediate purposes of a converged framework is to support the joint development and ongoing maintenance of converged standards, such as IFRS 15. It is also important to help these frameworks adapt over time to reflect changes in the market economy. Notably, the U.S. GAAP's current version is more recent than its IFRS counterpart.

Recent research has introduced ontological engineering methods to address the formal conceptualization of the International Accounting and Financial Reporting Standards (IFRS) framework [1], conceptualized as the CF Ontology [3, 4]. This approach fosters interoperability across various landscapes/domains, addressing ambiguities and enhancing the conceptual consistency of the framework. As depicted in Figure 1, such framework ontologies should be

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grounded in unified foundational ontologies, in this case in UFO [5] and in an already large set of UFO-grounded core ontologies [6-13]. The next step involves specialization of the CF Ontology for creating IFRS standard ontologies, such as for IFRS 15 *Revenue from contracts with customers* [14] highlighted in [15]. Furthermore, there is a need for the convergence of different frameworks and standards and the development of converged standards and ontologies. This paper explores the convergence between the CF Ontology for IFRS and the CF Ontology for U.S. Generally Accepted Accounting Principles (US GAAP). Additionally, future research will focus on the connectivity of these financial reporting frameworks with sustainability standards, addressing the increasing demand for integrated reporting that encompasses both financial and non-financial information, and explaining the sustainability-related risks and opportunities arising from an entity's activities and its assets and liabilities [16].

The ontological analysis of IFRS and converged standards has uncovered further opportunities for generalization and convergence, extending to the framework level. Upon review and discussion of the proposed ontologies, as well as comparing them with other UFO-based economic and legal ontologies, such as OntoFine [10] and UFO-L [13], it is evident that the conceptualizations introduced vary or require further meaning negotiation and explication. Key concepts needing clarification include Economic Resource [11], Control [17, 18], Agency, Transfer [13, 19], Capabilities [12] and Services [13].

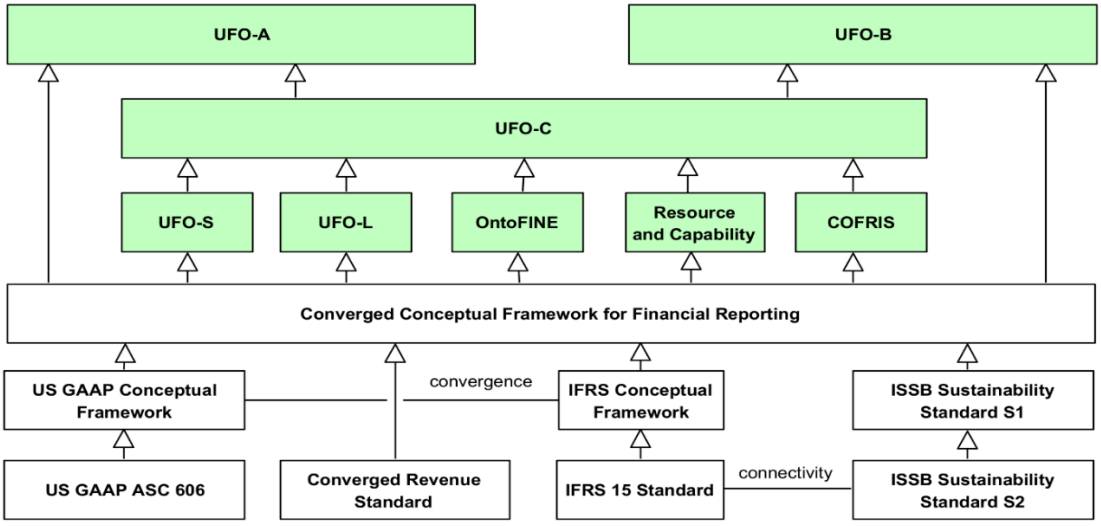

Figure 1: Principal diagram of developing Ontologies of Accounting Standards. Connectivity – a requirement to provide information in a manner that enables users of financial reports to understand the connections between the items to which the information relates and the connections between disclosures provided by the entity [16].

The problem of engineering ontology for economics and accounting has been regarded before, e.g. [18], however [3] is the sole documented effort exclusively focused on the (previous iteration of the) IFRS CF itself. Other efforts were devoted to the ontology of Economic Exchange and its use in accounting. Several ontologies for economic exchange were proposed grounded in UFO, and in a recent work, they have been consolidated for standard setting [20].

The research goal of this study is to study the problem of ontology convergence and to create an analysis and core ontology artifact – Converged Conceptual Framework (CCF) Ontology, grounded in the UFO and Core Ontology for Financial Reporting Information Systems (COFRIS) [20], as a formal model for convergence of the frameworks of the International Financial Reporting Standards (IFRS CF) [1] and the United States Generally Accepted Accounting Principles (US GAAP CF) [2].

The overall research frame is Design Science Research where COFRIS [20, 21], as it has been developed along several cycles so far, is the core artifact. The current paper represents a new design cycle; the primary research goal is to validate the usefulness of COFRIS by applying it to the practical purpose of CF convergence and to extend COFRIS if needed.

We start with a concise overview of the IFRS Conceptual Framework, its counterpart within the U.S., and definitions of the used social concepts from UFO-C and COFRIS, in Section 2. In Section 3, we introduce the CCF Ontology in OntoUML and propose motivated suggestions for convergence and generalization of frameworks. Section 4 concludes and outlines further validation work.

2. Background

2.1. The IFRS Conceptual Framework (IFRS CF)

The International Accounting and Financial Reporting Standards Conceptual Framework (IFRS CF) [1] sets out the fundamental concepts that guide the standard-setters in developing international accounting and financial reporting standards.

The *Objective of Financial Reporting* is to provide financial information about the reporting entity (aka *Enterprise*) that is useful to existing and potential investors and creditors in making decisions relating to providing resources to the entity.

Financial Reports provide information about (a) the nature and amounts of the entity's *Economic Resources* and the *Claims against the Entity*; (b) the effects of *Transactions and Other Events* that change an entity's economic resources and claims; (c) the efficiency and effectiveness with which the entity's management discharged their stewardship [and custody] responsibilities.

2.2. The US GAAP Conceptual Framework (US GAAP CF)

Numerous other accounting and financial reporting frameworks exist, each tailored to different activities and jurisdictions. A significant counterpart to the IFRS CF is the United States Generally Accepted Accounting Principles Conceptual Framework for Financial Reporting (US GAAP CF) [2]. US GAAP CF shares the same purpose and objective as IFRS CF. However, while there is a declared intention to minimize differences across these frameworks and standards, considering variations in legal, regulatory, or social norms [2], there are substantial specificities, and in 2014 the joint work program was discontinued. Generally, the US GAAP CF seemingly contains a broader array of core concepts than in IFRS CF, such as specific Transactions and Other Events, Economic Exchange, and Service Provision [2]. The US GAAP Framework defines ten core elements in contrast with IFRS CF's five elements [1]. The US GAAP CF has dismissed the asset control and custody concepts present in IFRS CF and exhibits differences in core element sets and definitions.

2.3. Unified Foundational Ontology (UFO)

Unified Foundational Ontology (UFO) is an axiomatic domain-independent formal Theory. UFO is divided into three layered compliance sets: UFO-A, an ontology of concrete *endurants* – of *substantials* and *aspects* [5], UFO-B, an ontology of *events* [6], and UFO-C, an ontology of *intentional* and *social* entities [7]. OntoUML is a language whose meta-model has been designed to comply with the ontological distinctions and axiomatization put forth by UFO [8]. OntoUML diagrams (e.g., Figure 2) represent types[‡].

Social commitments and claims specialize *social aspects* [7]. A *social commitment* is the commitment of an agent (a *committer*) against another agent (a *claimer*). As an externally dependent

[‡] OntoUML diagrams encompass both first order and higher-order types. For our modeling approach, we distinguish entities based on their instantiation status within the model. If an entity exists as an actual instance after the model's instantiation, such as a specific Tesla Model Y with chassis #123 involved in a delivery event #345—essentially, any entity that exists in the past or present—it is represented as a first-order type.

Conversely, if the entity is expected to manifest in the future (e.g., a Tesla Model Y specified within a purchase order), it is represented as a higher-order type. Unfortunately, the OntoUML currently does support modeling of different sorts of higher-order types as discussed in [22].

For similar reasons, we utilize primitive relations, such as *creation* and *termination*, to associate not only events with objects but also to associate *modes* that represent the intention behind the creation or termination of objects specified by higher-order types.

mode, a social commitment is a *characterization* of the committer, has *externalDependence* on the claimer, and causes the creation of an *internal commitment* in the committer [7]. Also, *correlative* to this internal commitment, a (*comparative*) *social claim* of the claimer against the committer is created. Commitments and claims always form a pair that refers to unique propositional content. A *social relator, mediated* by agents, is an example of a *relator* composed of correlative commitments/claims. *Actions* are intentional *events*, i.e., events that are performed by agents to satisfy their goals. Actions are *manifestations* of agent modes and action types are specified in commitment schedules or through committed resource types [7].

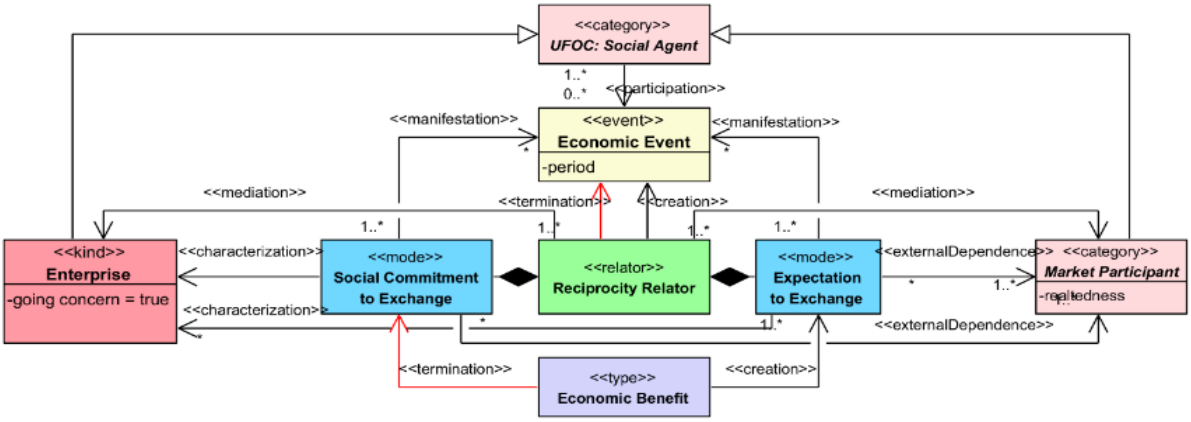

Figure 2: OntoUML diagram of Reciprocity Relator. Inspired by [9]. Enterprise view. In all diagrams, types are represented in purple, objects in pink, modes in blue, events in yellow, and relators in green.

Reciprocity Relators [9, 20], see Figure 2, relate *Social Commitments to Exchange* (or correlative *Claims to Exchange*) *Economic Benefits* of *each* of the two agents, e.g., the enterprise as a *Going Concern* and the other *Market Participant(s)*, as in contracts. The services ontology UFO-S [9] regards reciprocity relator as an agreement to exchange service actions. Initial phases of the reciprocity relator relate enterprise conditional commitments or offerings with expectations. The other market participants involved in a reciprocity relator may be independent or maintain related party relationships with the enterprise, characterized by varying degrees of *Relatedness*, potentially positioning the enterprise as a principal to its agents. *Economic Events create* or *terminate* reciprocity relators or manifest their respective *modes* through the execution of economic exchanges.

2.4. Core Ontology for Financial Reporting Information Systems (COFRIS)

COFRIS [20] adds economic resource flow and affected resource stock concepts to the commitments/ obligations and their fulfillment conceptualized in [9]. Furthermore, *Economic Resources* are considered as a set of institutional rights that have the potential to produce economic benefits. The term *Economic* when used as an adjective, refers to the monetary valuation or financial aspect of a given concept. In some cases, this qualifier is implicit and may be omitted when contextually understood.

In COFRIS Economic exchanges are specialized institutional actions in which two economic agents (A and B) establish and fulfill reciprocal performance obligations, typically through a contract. These obligations involve the transfer of control over economic resources and the provision of services, ultimately impacting both parties' resources and activities. The primary objective of such exchanges is to generate economic benefits for either or both parties involved.

The accounting for economic exchanges begins with the recognition of performance obligations. Fulfillment of these obligations occurs through the transfer of economic resources, which are specified by the resource types outlined in the contract.

The transfer of resources entails the execution of one agent's control or power over the resource, resulting in the termination of that agent's rights and the simultaneous creation of equivalent rights for the other agent. This transfer assumes that the receiving party can generate economic benefits from the acquired resource, either independently or in combination with other transferred resources or those freely available to the other party. A transfer action (1) may involve the actions of conduct – (2) service provision and (3) object delivery. Service provision refers to a simultaneous transfer of service rights and execution of specified action for the benefit of the other party. Notice a difference between service rights transfer, whereby a service provider is hired to stand ready for their execution, and service provision which is rights transfer with their simultaneous execution.

Fulfillment of performance obligation causes *Accrual* of a reciprocal conditional economic claim against the other party, fulfillment of all performance obligations of a contract creates an unconditional claim. Besides resulting from the fulfillment or valuation of a contract, economic claims can be constructive or created by law.

In addition to economic resources, economic claims can be transferred and exchanged. The transfer of claims entails the execution of one agent's agreed control or power over the claim of the other party, resulting in the termination of that agent's obligation and the simultaneous creation of an equivalent obligation for the third party, usually with the consent of the other party. The opposite operation of the transfer of an economic claim against one party is the assumption of this claim by the other party.

3. Converged ontology of conceptual frameworks for financial reporting (CCF Ontology)

This Section presents the Converged CF Ontology by (1) presenting core concepts used in both frameworks (IFRS and US GAAP), (2) conducting ontological analysis by visually representing and exploring the nature of these concepts through OntoUML diagrams, (3) suggesting and motivating the core concepts of the converged ontology. Our primary focus in this paper is on the convergence of elements within financial statements. The questions to be answered in a converged way are:

1. What are the economic resources and claims of the enterprise, their control and deployment rights and obligations?

2. What are the core economic events and their dispositions, participants, and effects?

Building upon the foundation laid by COFRIS, CCF Ontology takes a broader perspective by encompassing not only "pure" economic exchanges, but also production and transactions with owners that are "analytically useful to treat like" exchanges [27, 17], service provision, and other events, roles, and phases of resources and claims additionally required for the frameworks.

We consider the roles and phases of enterprise Economic Resources and Claims in Subsection 3.1, Table 1, and Figure 3, then transactions and other events and their effects on Resources and Claims in Subsection 3.2, Table 2, and Figure 4.

The concepts and terminology have been refined to align closely with those used in established frameworks, with particular attention given to cross-lingual validation using GPT-4 for term testing, including the nuanced selection of terminologies, such as differentiating between *Transferred Resource* and *Resource Transferred*. It is assumed that for most concepts, corresponding *higher-order types* and *correlative* counterparts of concepts exist.

The UFO foundational concepts will be denoted in camelCase Arial italics, such as *roleMixin* but CCF Ontology concepts in Arial italics, starting in uppercase – *Economic Resource*.

The Terms *Enterprise* and [*Reporting*] *Entity* are used interchangeably. The existing frameworks and CCF Ontology have the reporting entity perspective as opposed to the independent view [18, 20]. We assume that the Enterprise is a *Market Participant* in some *Environment* and holds *Economic Resources* and *Economic Claims against the Entity* from other parties that are

affected by *Economic Events* - transactions and other events with enterprise *participation*. Within its *Business Activities*, the enterprise enters into transactions with other market participants to maximize equity for its owners.

An *Economic Claim against the Entity* from other parties is abbreviated as *Claim From Others* or simply *Claim,* while *an Economic Claim of the Entity* to other parties is a *Claim To Others.*

We combine the institutional actions of *Economic Resource Transfer* to the other party and *Claim Assumption* from the other party as an *Outflow*. Conversely, *Inflow* combines *Economic Resource Receipt* from the other party and *Claim Transfer* to the other party.

3.1. Economic Resources of the Enterprise and Claims against it

To achieve the ontological convergence, we follow the ontology matching procedure of [23]. We start with identifying similar or equivalent elements reflecting financial position across the frameworks. Table 1 shows the definitions of elements by frameworks and our suggestions and preferences for the convergence in *italics*. In certain instances, we identify elements, such as *Revenue*, related to one framework in the standards of another (i.e., on a lower level). In such cases, the element from the second standard can provide additional context or enhancement to the first framework. Subsequently, we establish semantic mappings between entities from different ontologies and consolidate equivalent or aligned entities into unified representations. Any semantic conflicts, such as naming discrepancies, variations in definitions, and inconsistencies in constraints, are resolved by prioritizing the definitions provided by IFRS. All these steps are aligned with the shared Unified Foundational Ontology (UFO) and its sub-ontologies. If a concept does not align with or specialize an existing concept in the upper ontology, it is redefined accordingly. However, in the past, we have experienced a situation when our conceptualization influenced upper ontologies [8]. The outcome is the development and validation of the converged ontology, represented in OntoUML. Having achieved an initial match between the two standards, we continue by describing the grounding of these elements in UFO depicted as the OntoUML diagram in Figure 3 and our motivation for resolving semantic conflicts of both frameworks and creating unified representations.

An Economic Resource, such as homeownership, is a subkind of Reciprocity Relator mediating the enterprise with the Market Society relating an Enabling Right to Exchange, e.g., a right to sell a house, and reciprocal *Economic Benefit Potential,* e.g., receiving a payment. The rights to exchange may either arise from ownership over a particular physical or social *Object*, e.g., a house, rights to receive *Services* or other resources of a certain *type,* e.g. housekeeping services, or *Rights to Transfer a Claim* of the other party, e.g. transfer of a mortgage to the buyer of a house. The latter right is overlooked in accounting framework definitions but is implicitly recognized in actions described by standards such as IFRS 13 [24]. Therefore, it has been incorporated into the converged definition.

The US GAAP Conceptual Framework does not differentiate economic resources as a separate element, considering them synonymous with assets. The earlier UFO conceptualization in [11] is less detailed but also follows the synonymous approach. Our preference for the IFRS treatment of economic resources, as noted in [3], stems from its broader, more generic definition. This perspective recognizes economic resources not only as part of an entity's financial position (a *situation*) but also as participants in transactions, such as *Resource Transferred*. Additionally, an entity's own capabilities—such as control over the resource, as well as the recognition criteria and measurement principles, it applies—can differ from those in a more generic (i.e., market or transactional) context.

Table 1
Definitions of the core elements of financial position [1, 2] with our suggestions in italics.

Element	Framework	Definition or Description in IFRS and US GAAP Conceptual Frameworks
Economic Resource	*IFRS*	An [*enabling or entitling*] right that has the potential to produce economic benefits, *including the right to transfer an economic claim against the entity.*

Economic Claim	*IFRS*	An entitling right that corresponds to an obligation of another party
Economic Benefit		*Future Increases in economic resources or decreases in economic claims against entity*
Asset	*IFRS*: US GAAP:	A present economic resource controlled by the entity as a result of past events. A present right of an entity to an economic benefit.
Control	*IFRS*	An entity controls an economic resource if it has the present ability to direct the use of the economic resource and obtain the economic benefits that may flow from it, *either directly or through an agent acting on behalf of the controlling entity.* Control includes the present ability to prevent other parties from directing the use of the economic resource and from obtaining the economic benefits that may flow from it. *An agent may facilitate the obtaining of economic benefits or the prevention of others from obtaining such benefits, but the principal retains ultimate control.* It follows that, if one party controls an economic resource, no other party controls that resource.
Right to Deploy	*IFRS*	An entity has the present ability to direct the use of an economic resource if it has the right to deploy that economic resource in its activities, or to allow another party, *such as an agent,* to deploy the economic resource in that other party's activities.
~~Momentarily Asset~~	Both	Goods or services received and immediately consumed. *See Services in Subsection 3.2.*
Executory Contract	*IFRS* and US GAAP ASC 606	A combined right and obligation to exchange economic resources. The right and obligation are interdependent and cannot be separated. Hence, the combined right and obligation constitute a single asset or liability.
Economic Claim Against Entity	*Both*	Liability or Equity Claim. *An obligation that has the potential to sacrifice economic benefits, including the obligation to assume a new economic claim against the entity.*
Liability	*IFRS*: US GAAP:	A present obligation of the entity to transfer an economic resource *to provide services or to assume a new claim against the entity* as a result of past events. A present obligation of an entity to transfer economic benefits - either to transfer cash or convey assets or to provide services or stand ready to do so.
Equity Claim	*Both*	The residual interest in the assets of the entity after deducting all its liabilities.
Obligation to Deploy	*IFRS*	A present obligation of an agent to transfer to a third party an economic resource controlled by the principal.
Unit of account	*IFRS*	The right *to inflow* or the group of rights, the obligation *to outflow* or the group of obligations, or the group of rights and obligations, to which recognition criteria and measurement concepts are applied.

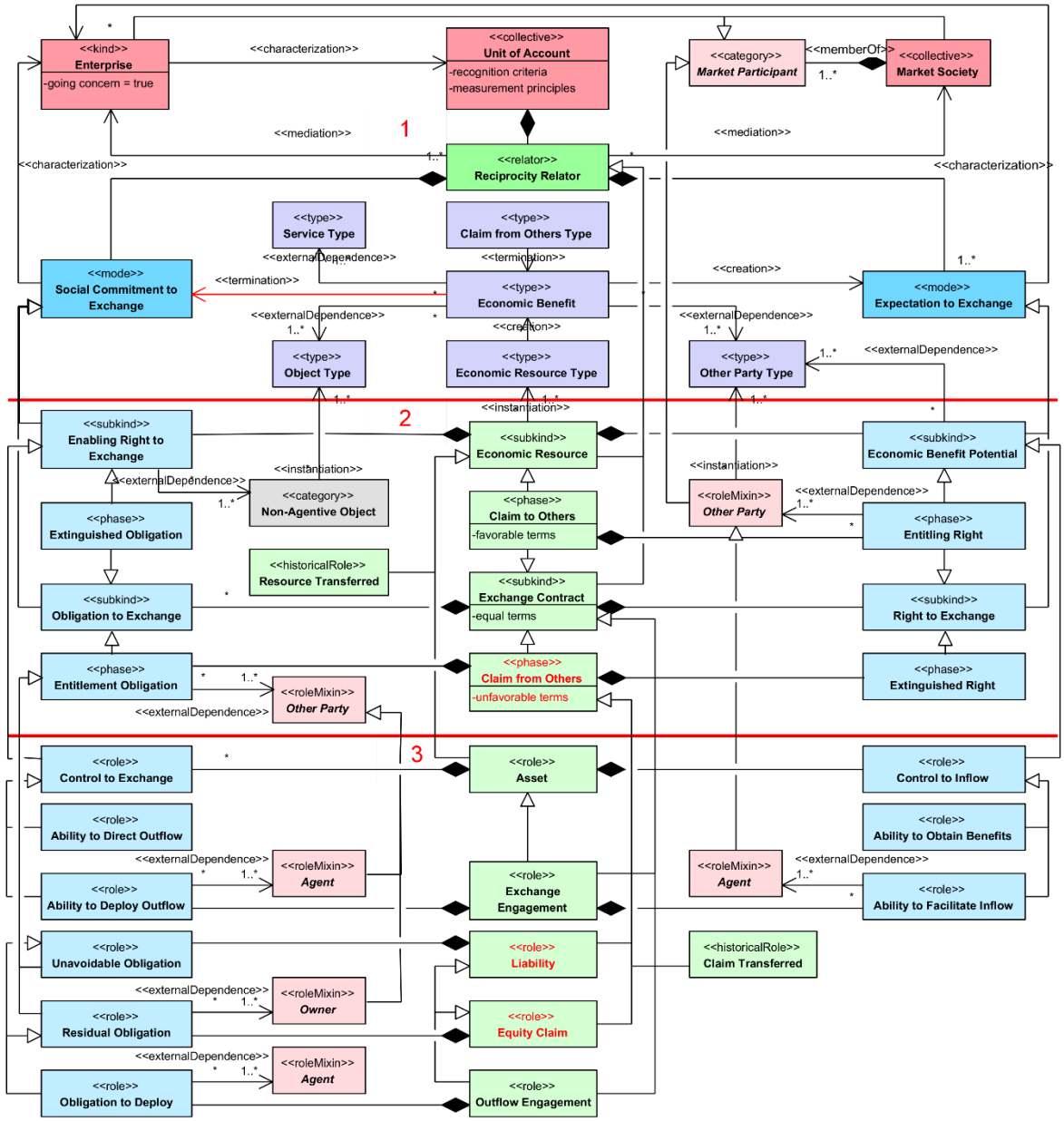

Figure 3: CCF Ontology. OntoUML diagram of Economic Resources and Claims. Enterprise View. Sections: 1. Reciprocity Relator, 2. Resources and Claims, 3. Assets, Liabilities, and Equity Claims.

This highlights the added dimension that an entity brings to its economic resources beyond what is reflected in generic market definitions. For example, intangible economic resources like software, control features as an asset include not only the software itself but also the rights to access, update, or use it, which may be specific to the enterprise holding the asset. Similarly, a house that has been acquired by an enterprise is classified as being used for production purposes, but not for sale.

US GAAP CF does not differentiate between enabling rights and entitling rights[§], thereby omitting the "potential to produce" characteristic found in the IFRS definition of economic resource. US GAAP suggests a more stringent recognition criterion. We prefer to emphasize enabling rights and the inherent uncertainty, as this distinction aligns with the asset-resource differentiation, allowing for a more nuanced and comprehensive characterization of economic resources. By focusing on enabling rights and uncertainty, a broader perspective is introduced, accommodating the various aspects of economic potential and resource utility beyond the more rigid asset recognition criteria.

[§] Sometimes also referred as *in rem* and *in personam* rights respectively.

Economic claims against other parties - when enabling rights have been *Extinguished* for the benefit of the other party, the *Entitling Rights* over economic benefits, such as receivables, are raised and the economic resource enters into the *Claim to Others phase*.

Economic Benefits are understood as a result of the *creation* of economic resources or *termination* of claims, thereby enhancing the entity's economic position. These benefits are the foundation of financial value and serve as the outcome of economic exchanges. This is our suggestion instead of rather long definitions in the frameworks, that as one standard-setter answered, "economic benefit is difficult to define".

Economic rights and obligations are *modes* inhering in the enterprise and other parties and are manifested by actions. These rights and obligations govern future transfers and receipts (assumptions and transfers) of economic resources (resp. claims). Consequently, specified economic resources and claims are modeled as higher-order types. Modes progress through different phases, raising phases of economic resources and claims.

Assets, such as crude oil (economic resource) as a raw material (role) or homeownership as an investment property, specialize economic resources that are held and controlled by an enterprise. These assets serve specific purposes aligned with the enterprise's objectives and are subject to unique restrictions, controls, and accounting treatments, including recognition, measurement, and valuation based on their intended use and the economic benefits they are expected to generate.

Control encompasses both the ability to direct the use of a resource and to obtain economic benefits from it, as well as the right to manage outflows and facilitate inflows.

Control to Exchange and *Control to Inflow* refer to the ability of the enterprise to realize the potential of the resource within some business activity type. Unlike IFRS, US GAAP CF does not explicitly recognize the concept of control, which we find particularly important, especially when considering transfer and agency issues. Control involves the *Ability to Direct* and *Ability to Obtain Economic Benefits* and the *Ability to Deploy Outflow* and *Ability to Facilitate Inflow*. For the latter two an *Exchange Engagement* with an *Agent* is possible, potentially separated for deployment and facilitation of obtaining and prevention. It also brings up the question about the transferability of control, assets, and liabilities, as regarded in Subsection 3.2.

An *Exchange Contract,* another subkind of Reciprocity Relator*,* mediates the enterprise with the *Other Party* that specializes *Market Participant*. Contracts have inseparable *Rights* and *Obligations to Exchange* economic resources or claims, mutually agreed upon between two parties. *Executory Contract* is a *phase* of an equally unfulfilled contract with the net cash flow value typically equal to zero. Contracts, resources, and claims are not static; they are subject to fulfillment, extinguishment, and fluctuating valuations. Therefore, we conceptualize them as distinct but interconnected phases within their lifecycle.

A *Claim to Others*, such as [account] receivable, arises from a contract when *Rights to Exchange* are predisposed to yield economic benefits—specifically, eventual inflows that are either greater than outflows of the related *Obligation to Exchange* or no such obligations exist.

A *Claim from Others*, such as payable, arises from a contract if the outflows are greater, or no rights exist and stems from the fulfillment of the *Obligation to Exchange* or the valuation of the contract. It can also be a participant in transactions as *Claim Transferred*.

A *Liability* specializes *Claim from Others* that the enterprise has no practical ability to avoid. In its definition in Table 1 we emphasize the transfer of services because in this case, the transfer of rights takes place simultaneously with service provision.

An *Equity Claim* specializes residual *Claim from Others* – from the entity's *Owners* and represents the owners' interest in the *Equity* - the assets of the entity after deducting all its liabilities.

The *Outflow Engagement* with the *Agent Obligation to Deploy* specifies a present obligation of an agent to transfer to a third party an economic resource controlled by the principal.

The US GAAP does not include control and agency-related concepts in CF, which is the reason for choosing more comprehensive IFRS CF definitions, elaborated in IFRS 15.

The *Unit of Account*, a *collective* of *Reciprocity Relators*, is the right or the group of rights, the obligation or the group of obligations, or the group of rights and obligations, to which recognition criteria and measurement concepts are applied [1]. The rationale for grouping or separating rights and obligations into particular Unit of Account is a matter of particular standards.

3.2. Transactions and other events

Per [25] much of financial reporting is currently transaction-based and will continue to be so. Transactions and other events result in [*gross*] increases in equity (such as income) and [*gross*] decreases in equity (such as expenses), typically accompanied by corresponding changes in assets and liabilities, ensuring that the fundamental equation, Assets = Liabilities + Equity Claim, remains balanced and intact. In Table 2 we have accumulated definitions of changes in equity from both frameworks and standards grouped by *Transaction or Other Event* type as a main criterion for naming these changes, allowing us to combine the differences in naming.

Table 2
Transactions and Other Events Represented as Changes in Equity

Change in Equity	Framework	Definition or Description in IFRS and US GAAP Conceptual Frameworks
		1. Changes in economic resources and claims reflecting financial performance.
Income	*IFRS*	Increases in assets, or decreases in liabilities, *or goods or services received and immediately consumed,* that result in increases in equity, other than those relating to contributions from holders of equity claims.
Expenses	*IFRS*	Decreases in assets, or increases in liabilities, *or goods or services received and immediately consumed,* that result in decreases in equity, other than those relating to distributions to holders of equity claims.
		1.1 Changes from ordinary activities
Revenues	US GAAP	Inflows or other enhancements of assets of an entity or settlements of its liabilities from delivering or producing goods, rendering services, or carrying out other activities.
	IFRS 15	Income arising in the course of an entity's ordinary activities when transferring goods or services to customers in exchange for consideration.
[*Operating*] Expenses	*US GAAP*	Outflows or other using up of assets of an entity or incurrences of its liabilities from delivering or producing goods, rendering services, or carrying out other activities.
		1.2 Changes from not ordinary activities
Gains	*US GAAP*	Increases in equity from transactions and other events and circumstances affecting an entity except those that result from revenues or investments by owners.
Losses	*US GAAP*	Decreases in equity from transactions and other events and circumstances affecting an entity except those that result from expenses or distributions to owners.
		2. Changes in economic resources and claims not reflecting financial performance
		2.1. Transactions with Owners
Investments from Owners	*US GAAP*	Increases in equity of an entity resulting from transfers to the entity from other entities of something valuable to obtain or increase interests (or equity) in the entity.
Distributions to Owners	*US GAAP*	Decreases in equity of an entity resulting from transferring assets, rendering services, or incurring liabilities by the entity to owners. Distributions to owners decrease ownership interest (or equity) in an entity.
		2.2. Other changes
None	*Both*	Exchanges of assets or liabilities that do not result in increases or decreases in equity.

In Figure 4 we depict the converged ontology of transactions and other events grounding it in UFO. Economic Outflow and Inflow events are fundamental components of Transactions and Other Events. These events may occur independently as environmental or market phenomena, such as impairments or value changes, or as manifestations of Obligations and Rights arising constructively,

by law, or through exchange contracts. In the latter scenario, the fulfillment of non-terminal phases of Obligations or Rights to Exchange also triggers accrual[**] or reciprocal events.

Outflows involve the *Resource Transfers* to other parties and the *Assumptions* of *Claims* from other parties. These actions result from the *Decreases in Assets, Increases in Liabilities*, and the consumption of *Services Provided,* leading to *Decreases in Equity.*

The *Fulfillment* of *Obligations to Exchange* or *Entitlement Obligations* results in *Extinguished Obligations.* Furthermore, outflows advance unfulfilled *Rights to Exchange* into *Entitling Rights* which trigger the *Accrual* of *Claims to Others* leading to *Increases in Equity.*

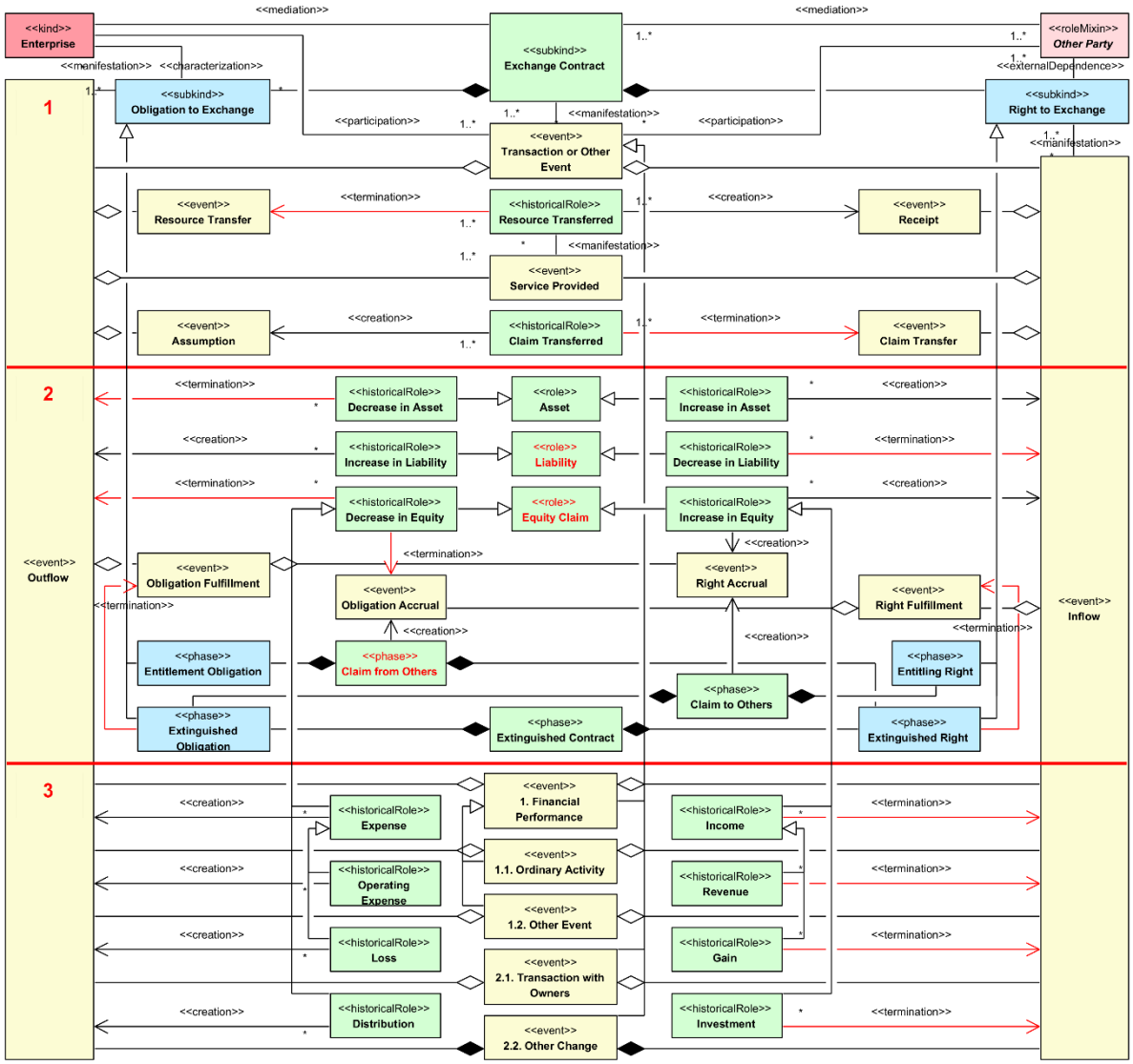

Figure 4: CCF Ontology. OntoUML diagram of transactions and other events. Enterprise view[††], [‡‡] Sections: 1. Transfers, 2. Accounting effects, and 3. Changes in equity specialized by economic event type.

[**] Accrual accounting depicts the effects of transactions and other events and circumstances on a reporting entity's economic resources and claims in the periods in which those effects occur, even if the resulting cash receipts and payments occur in a different period. [1, 2]

[††] One reviewer questioned the validity of the <<characterization>> relation between <<kind>> and <<subkind>> in Figure 4. However, we, along with the OntoUML verifier, have confirmed its validity. The <<characterization>> relation in question is appropriately established between the Enterprise and the Obligation, which is a <<subkind>> of the Social Commitment <<mode>> depicted in Figure 3.

[‡‡] Aggregation relations between events are used instead of <<historicalDependence>> relations.

Inflows involve the *Resource Receipts* from other parties or the *Claim Transfers* to other parties. These actions result in *Increases in Assets, Decreases in Liabilities*, and the consumption of *Services Provided,* leading to *Increases in Equity.*

The *Fulfillment* of *Rights to Exchange* or *Entitling Rights* results in *Extinguished Rights.* Furthermore, inflows advance unfulfilled *Obligations to Exchange* into *Entitlement Obligations* which trigger the *Accrual* of *Claims from Others* leading to *Decreases in Equity*.

The progression of both obligations and rights into their extinguished phases results in the exchange contract transitioning into its *Extinguished Contract* phase.

All changes in equity are categorized based on the *type* of *Economic Event*, the *Nature* and *Roles* (*Functions*) of the agentive and non-agentive participants in the entity's business activities, and the methods used to measure these changes.

In addition to the general pattern described above, changes in equity are recognized specifically depending on the type of event. First, the transaction or event is categorized as whether it is within the scope of the *Financial Performance* of the enterprise. In this case, the *Expense* specializes *Decrease in Equity* and the *Income* specializes *Increase in Equity*.

Second, within the first, the transaction or event is categorized as whether it is within the scope of *Ordinary Activities* of the enterprise. In this case, the *Operating Expense* specializes *Expense* and *Revenue* specializes *Income*. This follows from the US GAAP CF and IFRS 15.

Otherwise, if not within ordinary activities, *Loss* specializes *Expense* and *Gain specializes Income*.

For changes in economic resources and claims that do not reflect financial performance, we have *Operations with Owners* and *Other Changes*. For operations with owners, *Distribution* specializes *Decrease in Equity* and *Investment* specializes *Increase in Equity.* The US GAAP CF in contrast with IFRS has special elements for owner transactions [2] that indicate some construct deficit in [1].

The remaining are "Exchanges of assets or liabilities that do not result in increases or decreases in [net] equity" [1] and do not reflect financial performance. Changes in equity typically are not recognized for these inflow and outflow events, e.g., for purchase transactions.

However, under US GAAP, transactions with owners are included as separate elements of financial statements—specifically, 'Investments by Owners' and 'Distributions to Owners.' This inclusion, along with discussions on defining elements in terms of cash inflows and outflows (as elaborated in paragraph C4.97 of the Basis of Conclusions on the IFRS Conceptual Framework [25]), supports the perspective that categorizing changes in equity at the transaction level for each inflow and outflow provides ontologically meaningful insights into the economic events of an entity. Whether this categorization is significant for presentation or disclosure purposes depends on the specific requirements of the applicable accounting standards.

Important components of transactions and other events are transfers of economic resources and claims, and service provision - services received that are immediately consumed.

Using legal concepts regarded in [13] we define *Transfer of Rights* as institutional action in which a holder of an economic resource, leveraging its legal power to create or modify legal relations, terminates the holder's rights to the resource and simultaneously creates equivalent rights for another party who is initially under a legal disability.

IFRS 15 [14] and the converged ASC 606 [26] introduce the concept of *Transfer of Control* as a criterion for revenue recognition. Additionally, they treat assets (and liabilities in other standards) as the objects of transfer. We question this approach, as control encompasses certain capabilities of an enterprise, as understood in the [12], which are inherently complex to identify and transfer. This distinction directs us back to the fundamental difference between economic resources and assets. Economic resources encompass transferable rights and are understood not only in terms of their legal status but also either by the market society's (or shared by the agreement with the other party) understanding of the resource's capabilities and the availability of other components necessary to realize those capabilities.

Consequently, the transfer of control should include rights and capabilities of economic resources underlying assets but not the rights and capabilities specialized by the assets inhering in the enterprise.

Both frameworks introduce a *Momentarily Asset* concept for goods or services received and immediately consumed. That makes the definitions of the elements shorter. However, in UFO [9], service delivery is a complex event (not an endurant) characterized by its temporal nature and the immediate co-consumption by the service recipient. Also, SNA [27] finds that service production is an *activity* that cannot be conceived without its simultaneous consumption. The CCF Ontology models momentarily assets as *Services Provided* and adjusts the changes in equity definitions in Table 2. This is also reflected in Figure 4 whereby changes in equity can be created by Service provision event. An example of recognizing service production and consumption as pure changes in equity is the recognition of revenue in a barter transaction. In such a transaction, the value of the goods transferred is measured by the fair value of the services received and consumed as consideration.

An example of a sales transaction scenario is represented in Table 3, formatted as an event table [32]. In transaction #1, the enterprise—a car dealership—transfers a car to a customer as part of its *ordinary activities* for $29,500, plus $1,000 worth of cleaning services provided by the customer. The cleaning *services are immediately received and consumed.* The cost of the car to the dealership is $20,000.

In transaction #2, the dealership *assumes* a $500 registration fee payable to a third party (the DMV), which is reimbursable by the customer (as part of the *other events* of the enterprise).

The third transaction is the fulfillment (F) of the registration fee payable to the DMV assumed in transaction #2. In the table, "+" indicates an increase, while "-" indicates a decrease.

Table 3
Example of a Sales Transaction

Flow									Stock			
#	F #	Economic Event	Other Party	+ -	Flow Element	Resource or Claim	Third-Party	Amt $	+ -	Stock Element	Other Party	Amt $
1		Transfer	Customer	-	COGS	Car		20,000	-	Inventory		20,000
		Accrual		+	Revenue	Receivable		29,500	+	Receivable	Customer	29,500
		Receipt	Customer	+	Barter Revenue	Services		1,000				
		Consumption		-	Expense	Services		1,000				
2		Assumption	Customer	-	Loss	Fee to	DMV	500	+	Fee to	DMV	500
		Accrual		+	Gain	Receivable		500	+	Receivable	Customer	500
3	2	Transfer	DMV	-	Cash Outflow	Cash		500	-	Cash in Bank	Bank	500
		Fulfillment		+	Fulfillment	Fee to	DMV	500	-	Fee to	DMV	500

4. Conclusion and future work

Grounding in UFO and COFRIS social and economic endurants, events, and their *primitive* relations we have developed a Converged Ontology of the IFRS and US GAAP Conceptual Frameworks for Financial Reporting. This ontology is a novel attempt to describe the core transactions and other events, the elements for financial reporting. It charts the path for setting standard ontologies through framework specialization, framework improvement via convergence, theory and technology adaptation, and standard generalization.

In our development process, we have refined the distinctions between economic resources and assets, clarified the dual nature of economic claims against an entity, and identified the participants involved in inflows and outflows. Additionally, we have addressed issues surrounding the transfer of economic resources, differentiated between services and "momentarily assets", and developed a converged taxonomy of economic transactions and other events.

The need to converge concepts necessitates their unification while excluding contradictions, ensuring that the converged concept is grounded in an upper-level ontology and effectively

specialized at the lower levels. Convergence can significantly enhance or refine a concept; however, care must be taken to prevent it from becoming overly broad or abstract. Achieving convergence between frameworks requires an in-depth analysis of standards to identify a shared conceptual foundation. Success in this process is marked by identifying higher-level concepts rooted in established theories or the Unified Foundational Ontology (UFO).

The bias toward IFRS in a converged framework arises from the desire for global applicability, principles-based flexibility, alignment with economic substance, and regulatory preferences for simpler, more uniform standards. This makes IFRS a more appealing foundation for a unified set of global accounting standards compared to the more detailed and rules-heavy US GAAP.

The observed need to delve into the IFRS 15 and converged US GAAP ASC 606 is because this standard reflects the core concepts of economic exchange, and in some sense is more fundamental than the frameworks.

UFO Ontology matching and convergence remains mostly a costly manual process. However, the attempts to automate it open a new perspective by using the means of LLM [28, 29] and exporting to OWL of OntoUML diagrams [30].

The resulting converged framework serves as a validation of COFRIS. Furthermore, the validation of the CCF Ontology itself should involve the modeling of converged standards, such as IFRS 13 [24], and addressing emerging challenges, like climate-related and other uncertainties in financial statements [31], which are pertinent to both frameworks. This approach not only verifies ontology's robustness but also ensures its relevance to contemporary financial reporting issues.

The CF Ontology diagrams were syntactically verified using OntoUML tools. The successful development of the CCF Ontology demonstrates the conceptual richness of the UFO and COFRIS ontologies and their suitability as ontological analysis means.

The CCF Ontology is submitted for publishing in OntoUML/UFO Catalog.

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