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An Ontology for Identifying Terms and Equivalents in the Domain of the Balance of Payments

Abstract

Terms are at the centre of terminology work as defined in ISO 1087-2019: identifying them in texts and finding equivalents for them in different languages is pivotal. This can, however, pose a challenge. Proceeding from the classical theory of the term as a linguistic representation of a concept "stable" over time, shared by domain experts, and built by specific differentiation, this paper presents an ontology-based method to identify terms and find equivalents. By representing all concepts of a subject field in a computer-readable form, we obtain an ontology that represents all identified concepts within the domain as well as the observable relationships among them. The method is applied to a portion of the domain of the balance of payments and international investment position. The paper shows how building an ontology using TEDI (ontoTerminology EDItor) can help to identify terms and find equivalents. The approach is semasiological – the work is corpus-based – as well as onomasiological – it relies on inputs by domain experts regarding both the linguistic and the conceptual dimensions.

Keywords: ontology, ontoterminology, balance of payments, onomasiological approach, semasiological approach

Introduction

Terms are at the centre of terminology work[1]: identifying them in texts and finding equivalents for them in different languages is pivotal. This can, however, pose a challenge. We have developed an ontology-based method to identify terms and find equivalents and applied it to a portion of the domain of the balance of payments and international investment position.

A term is a linguistic representation of a knowledge unit, *i.e.* of a concept. We regard a lexical unit as a term if it denotes a knowledge unit that is "stable" over time and shared by domain experts, and can be built by specific differentiation, *i.e.* by adding to its superordinate concept (*genus*) the characteristics that

1 Understood as the „work concerned with the systematic collection, description, processing and presentation of concepts (3.2.7) and their designations (3.4.1)" (ISO 1087-2019, 3.5.1).

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are "indispensable to understand" it (ISO 1087-2019, 3.2.3). If, according to this methodology, we are able to build all concepts of a subject field in a machine-readable form, we can constitute an ontology of the domain. Such an ontology gives a representation of all identified knowledge units within the domain as well as of the observable relationships between them.

In this paper, we show how building an ontology using TEDI (ontoTerminology EDItor) can help to identify terms and find equivalents. We apply the methodology to the domain of the balance of payments. The approach is semasiological – the work is corpus-based – as well as onomasiological – it relies on inputs by domain experts regarding both the linguistic and the conceptual dimensions. The purpose is to build an ontoterminology, *i.e.* a terminology whose conceptual system is a formal ontology. In its linguistic dimension, it represents a set of terms and equivalents in different languages, each with an Aristotelian definition, built according to the nearest hypernym and the specific difference.

The structure of the paper is the following: we first present the task we want to perform and the problems it implies (1), detail the environment considered as the state of the art in developing ontologies, and analyse whether this environment suits our purpose (2). We then indicate the tools used and our methodology (3) and present the specific application domain (4) and the results obtained (5). The paper ends with some preliminary conclusions (6).

1. Purpose and problems

The claim that it is possible to identify terms and equivalents by creating an ontology of the domain of interest relies on a certain number of assumptions.

The ISO 1087-2019 standard defines a term as a "designation that represents a (…) concept by linguistic means". This definition has a direct implication: it is impossible to identify and study terms without analysing concepts.

A first approach to the question can be based on a classic semiotic triangle, inspired by the one popularised by Ogden and Richards ([1923] 1953: 11), as well as on the Aristotelian theory of the concept. The latter denotes a mental object we construct to represent objects that belong to what we consider to be reality (these objects can be real, physical, logical, psychological, hypothetical, past, present, future, material, immaterial…). ISO 1087-2019 gives the following definition of a concept: "a unit of knowledge created by a unique combination of characteristics". We create and use concepts to refer to the objects we deal with in a knowledge-related activity, and we create and use terms that denote these concepts in natural language (see figure 1).

Concepts are embedded in a hierarchical structure in which some are superordinate while others are subordinate. That hierarchy results from the very way we build concepts. We attribute essential characteristics to knowledge units. The "set of characteristics that make up a concept" is called its intension (it is represented in figure 1 by "Σ (a+b+c)") (ISO 1087-2019, 3.2.6). Concepts are linked to each other according to their respective essential characteristics: a concept with a narrower intension (fewer essential characteristics) is located higher in the hierarchy and is called a superordinate concept. It is the *genus* of one or several subordinate concepts, which are called its *species*. In other words, a subordinate concept possesses an additional essential characteristic (also called its specific difference) that makes it what it is and distinguishes it univocally from its superordinate. If concept A is the *genus* (superordinate) of concept B, B necessarily inherits all essential characteristics of A, and possesses (at least) a specific one (see in fig-

ure 1 "Σ (a+b+c)" and "Σ (a+b+c+d)"). In other words, a superordinate concept always has an intension that is narrower than that of any of its subordinate concepts.

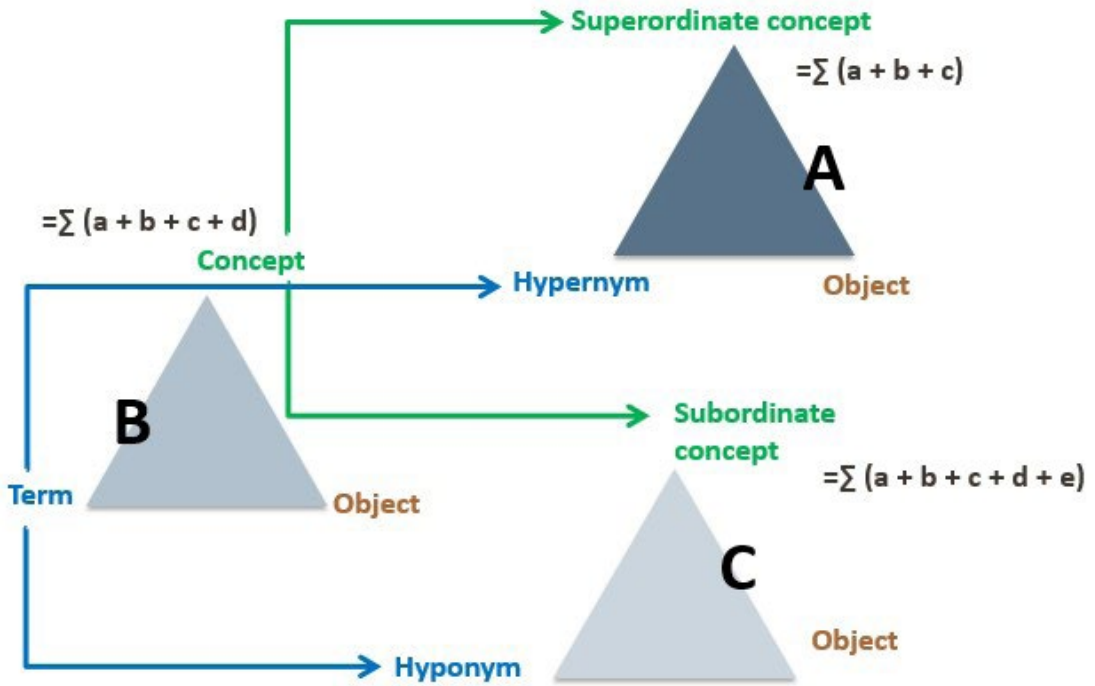

Figure 1: Relations among terms, concepts and objects

At the linguistic level, we call a lexical unit a term if it is a "designation that represents a (…) concept by linguistic means" (ISO 1087-2019, 3.4.2). In other words, to identify a lexical unit as a term, one has to assess whether it designates a concept. To determine whether ontology is a good candidate for this task, we must first clarify what we mean by ontology, as this term is used in the literature with numerous meanings.

We are not using the philosophical definition of ontology understood as the "study of being in general" or of "what there is" (Simons 2015: Introduction). The definition should give a satisfying response to the needs of terminology while at the same time taking account of the actual developments in the information society. For this, it is necessary to have a look at knowledge engineering. Gruber (2009: 1963) gives a short definition of ontology as "a set of representational primitives with which to model a domain of knowledge or discourse." In the knowledge creation process, we produce concepts by abstracting properties of things. Ontology is an object in which the elements of knowledge are represented as logical objects. It is the result of a modelling process and helps us in knowledge representation. With "primitives", we should understand "upper categories", which make it possible to mentally construct the domain of interest.

According to Studer et al. (1998: 25), ontology is "a formal, explicit specification of a shared conceptualization". It is necessary to explain each element in this very concise but information-rich definition oriented to computing. A "conceptualization" is explained as follows: "a body of formally represented

knowledge is based on a conceptualization: the objects, concepts, and other entities that are assumed to exist in some area of interest and the relationships that hold among them. A conceptualization is an abstract, simplified view of the world that we wish to represent for some purpose" (Genesereth and Nilsson, quoted in Guarino *et al*. 2009: 3). "Formal" refers to a formal language, *i.e*. the ontology should be written in a machine-readable format, NOT in natural language. With "explicit", we should understand that the ontology states all intended properties, in order to avoid misunderstanding. This can be done either extensionally (listing all possible elements, as in an extensional definition in terminology) or intensionally (more practical with large sets, by defining axioms or functions that permit inference of all possible elements, an approach that corresponds to the intensional definition in terminology) (Guarino *et al*., 2009: 8). By "shared", these authors mean that "the conceptualization should express a shared view between several parties, a consensus rather than an individual view" (Guarino *et al*., 2009: 2). This aspect is quite consistent with the necessity of sharing the content of the ontology.

In this paper we use the definition given by Roche (2007: 47), which is based on the definition given by Studer *et al*. (1998: 25) and states that an ontology is "a shared description of concepts and relationships of a domain expressed in a computer readable language". This definition adds the relationships existing in the domain to be modelled. It entails all elements that fit the needs of terminology: the description of concepts and relationships identified in a domain of interest (which we see as the core of terminology work), the importance of the experts (the fact that the description is shared between domain experts gives the ontology its validity and makes it reusable), and the need for operationalisation (the product has to be expressed in a computer-readable language, to permit knowledge sharing).

We will now present the postulate on which the methodology is built. Provided we have to do with a term, there is a concept behind it.[2] That concept may arise in a conceptual system (*i.e*. with superordinate and subordinate concepts) and that conceptual system may be constructed as a formal ontology. In other words, as the proof of the pudding is in the eating, it should be possible to prove the termhood of a lexical unit by performing another task … namely constructing an ontology, *i.e*. a conceptual system containing the concept that it denotes.

Before we go on, we should look at the criteria such an ontology must satisfy if we want it to help identify terms, synonyms and equivalents. The five following conditions are mandatory:

a. The ontology must represent the hierarchical relationships (*genus-species*) among the identified knowledge units in the subject field in a manner that makes it possible to univocally determine the generic and the specific concepts.
b. It must supply an interface with terminology in order to take account of the double dimension of terminology (linguistic and conceptual).
c. It must be understandable by its potential users (experts, junior users, language specialists, *i.e*. terminologists, translators …).
d. It must reflect the way domain experts think and the categories they use: domain experts are our best guarantee that a lexical unit really denotes a concept.
e. It must be machine-readable and fulfil the W3C standards[3] if we want it to be reusable and facilitate knowledge sharing and transfer.

2 In Terminology, there is by definition no term that does not denote a concept. In other words, we are not studying lexical units only as linguistic objects.

3 The Semantic Web Standards published by the W3C (https://www.w3.org/standards/semanticweb/ [date of access: 30.6.2020]) are aimed at easing transferability and interoperability of data.

2. State of the art in the field of developing ontologies

We will now briefly present the state of the art in the field of developing ontologies, focussing on Protégé, which is currently the most popular environment. The purpose here is to analyse how this tool behaves faced with the five criteria mentioned above.

The first version of the software was developed by a group at Stanford University (USA) at the end of the 1980s (Musen *et al.* 2015: 5). The current version is 5.0 (cf. https://protege.stanford.edu/). The software is based on Description Logics. The stress is put here on individual objects linked with one another by descriptions: an individual object does not acquire sense based on what it is, but on the relationships it has with other individual objects. The individual objects are structured in classes that can be defined by role restriction, *i.e.* by restriction of the relationships among individual objects (Roche 2020).

Protégé gives a representation of the hierarchical relationships of the domain under scrutiny and produces an output that is computer readable and fulfils the W3C standards.

But as Horridge *et al.* (2013) admit, "as the group that developed Protégé, the most widely used ontology editor, we are keenly aware of how difficult the users perceive this task [ontology engineering] to be". Indeed, contrary to good sense after René Descartes (1637: I), Description Logics on which Protégé is based is not "the most equally distributed of all things among men"! Protégé requires specific skills and cannot be understood by its potential users without a thorough training. As stated by Roche and Papadopoulou (2019: 3), the approach of Description Logics used in Protégé "is far from the theory of concept used in Terminology (…), where concepts are defined as combinations of essential characteristics, and where a term is a verbal designation of a concept". Moreover, tools like Protégé are "not as friendly for domain experts as they are for knowledge engineers".

To put it succinctly, by defining concepts as role restriction and not as a combination of essential characteristics, Protégé complies neither with the General Theory of Terminology[4], nor with the ISO definition of concepts (cf. ISO 1087-2019, 3.2.3), nor with the way domain experts think.

Moreover, Protégé has no specific interface that takes account of the double dimension of terminology. Protégé thus complies with our conditions a and e, but not with b, c and d. If we want to develop an ontology for terminology purposes and share its content, we will need to look for another tool.

3. Material and methods

3.1. Tools used

TEDI is a tool specifically developed for "building multilingual ontoterminologies (an ontoterminology is a terminology whose conceptual system is a formal ontology)".[5] It fulfils all five criteria mentioned:

a. it gives a representation of hierarchical relationships between concepts (with the help of a so called "Concept Editor");

4 According to which "the concept consists of an aggregate of characteristics which we can cognize as being common to a number of individual objects, and which we use as means for mental ordering and for communication" (Felber 1984: 103).

5 See http://ontoterminology.com/tedi [date of access: 30.6.2020].

b. it possesses an interface dedicated to the linguistic dimension of terminology (so-called "Term Editor");
c. it can be used by domain experts without requiring specific skills like programming or description logics, because
d. it actually reflects the very way domain experts build concepts by specific differentiation; and
e. it produces a computer-readable output complying with the W3C standards, by exporting its content into different formats for data sharing.

In other words, TEDI takes account of both the conceptual and the linguistic dimensions of terminology, and its architecture promises a perfect fit for the purpose of the task.

The ontology must be validated by domain experts in order to be reusable. It is developed with the help of TEDI, and will be converted with CMapTools, a tool for building concept maps representing all identified generic relationships among concepts.[6]

3.2. Methodology

The balance of payments and the international investment position, to which the methodology is applied, constitute a very complex domain (see section 4.). Building an ontology of the entire domain and submitting it to experts for validation would therefore exceed both the framework of this paper and the patience of the experts. This is why we have selected a small portion of the studied domain, namely the economic assets, and tried to develop a micro-ontology thereof using TEDI, based on the reference manual (IMF 2009). The assumption behind the choice of the reference manual is that, after Condamines (2009), corpora such as reference manuals are especially appropriate for building ontologies because they contain numerous linguistic markers. Indeed, authors of manuals often use definitory contexts or at least knowledge-rich contexts in order to explain a domain or a branch of activity.[7]

We then convert the micro-ontology in a format readable by the experts, submit it to them as a concept map, and evaluate their feedback.

Before we go further, a brief presentation of the domain under scrutiny is necessary.

4. Description of the domain of the balance of payments

The balance of payments and international investment position (BPIIP) is a practice-oriented field at the intersection of macroeconomics, statistics and national accounts. The reference manual, namely the Balance of Payments and International Investment Position Manual, 6th Edition (BPM6), published by the International Monetary Fund (IMF) in 2009, gives the following description of this domain: "The balance of payments is a statistical statement that summarizes transactions between residents and non-res-

6 See https://cmap.ihmc.us/, Florida Institute for Human & Machine Cognition [date of access: 30.6.2020].

7 To quote Condamines (2009: 6): "Il semble établi que les corpus les plus riches en marqueurs de relations et donc les plus susceptibles d'être utilisés pour construire des ontologies/terminologies sont les corpus de type didactique comme les « manuels ». En effet, les auteurs de manuels utilisent fréquemment des contextes définitoires ou du moins des contextes riches en connaissance destinés à faire comprendre un domaine ou une pratique pour des non-experts."

idents[8] during a period. It consists of the goods and services account, the primary income account, the secondary income account, the capital account, and the financial account" (IMF 2009: 9). More generally, the BPIIP is a statistical object that sums up all relations of an economy, *e.g.*, of a country or a group of countries, with the rest of the world, as well as all changes of ownership generated by these relations.

The export of goods or services is for example first captured by statistical means (statistical aggregates defined by the responsible authority, generally the central bank of the IMF member state in charge with establishing the BPIIP), and then recorded in accounts, based on the principles set out in the System of National Accounts 2008 adopted by the United Nations Statistical Commission[9]. Every transaction captured always implies at least one resident and one non-resident entity (a seller and a buyer in the most basic transaction, but transactions are generally much more complex). The central bank or the relevant statistics authority aggregates all similar transactions into objects within the statistical statement.

As a field of knowledge, the BPIIP has several features. The objects to which its concepts refer are themselves the product of a conceptualisation activity, and thus non-material. Indeed, the object "export" (or "import") of goods (or of services), for example, is a complex construction that includes several elements, of which only a few have a direct material dimension. Because all transactions and other flows are aggregated, so are the positions that are linked to them in the accounts. That is why the concept of export of goods by a given branch of an economy does not refer in the BPIIP to a specific material object but to the object in which it is accounted (IMF 2009: 9ff.) – and this object is non-material.

Secondly, the BPIIP is a social construct: the principles of its establishment are set out by IMF (2009). The reference manual delivers a conceptual system that is both stable and shared by a community of practice (namely the statisticians working at central banks). Accordingly, it is possible to name concepts in natural language with terms. But IMF (2009) does not have universal validity: it gives recommendations and central bank specialists may define and organise concepts according to the special needs of their economic or monetary area. Consequently, it may be possible to model different domain ontologies.

Because a BPIIP is being established for all IMF member states as well as for economic or currency unions such as the European Union and the euro area, there is a broad corpus of texts on the field published in different languages, which makes an ontoterminological study interesting.

IMF (2009) is available in six languages: Arabic, Chinese, English, French, Russian and Spanish. We use the English (original) version as a corpus and extract terms from it, which we then link to concepts.

5. Work done and results obtained

5.1. Work done

The domain is modelled in a machine-readable format using TEDI (see figure 2). This tool allows assignment to each concept of the characteristics necessary and sufficient for building it in the process of specific differentiation. For the active concept, considerable information can be entered or automatically

8 The original BPM6 text uses the US form "nonresident". We use UK orthography here.

9 For more information, see European Communities et al., 2009.

computed by TEDI, including the generic concept (*is a kind of*) and the inherited differences and own differences. The tool also makes it possible to manage different kinds of non-generic relations (causal, dependent on, equivalent to, has function, part of…) and to create domain-specific relations, a feature that promises to be very useful for future work.

TEDI automatically gives a name to each concept (see "Concept" field in the upper part of figure 2). That name is created using the upper-level concept (*e.g.* "Entity") and the concatenation of all differences (viz. differences inherited from all concepts above the one under scrutiny and the specific difference that distinguishes this concept from its immediate superordinate concept). In figure 2, the differences of the active concept are: /not entitled to own goods or assets in their own right/, /on which ownership rights are enforced/, /with the perspective of future economic benefits to the owner/ (*inherited*) and /with an unconditional corresponding liability/ (*own*). Only entities that possess all four characteristics are referred to by the active concept. The name given to the concept here is a kind of identifier. It is *not* a term.

Elements (in blue) in the lower part of figure 2 show the corresponding linguistic dimension linked to the displayed concept: in addition to the term, its definition in natural language is computed after the

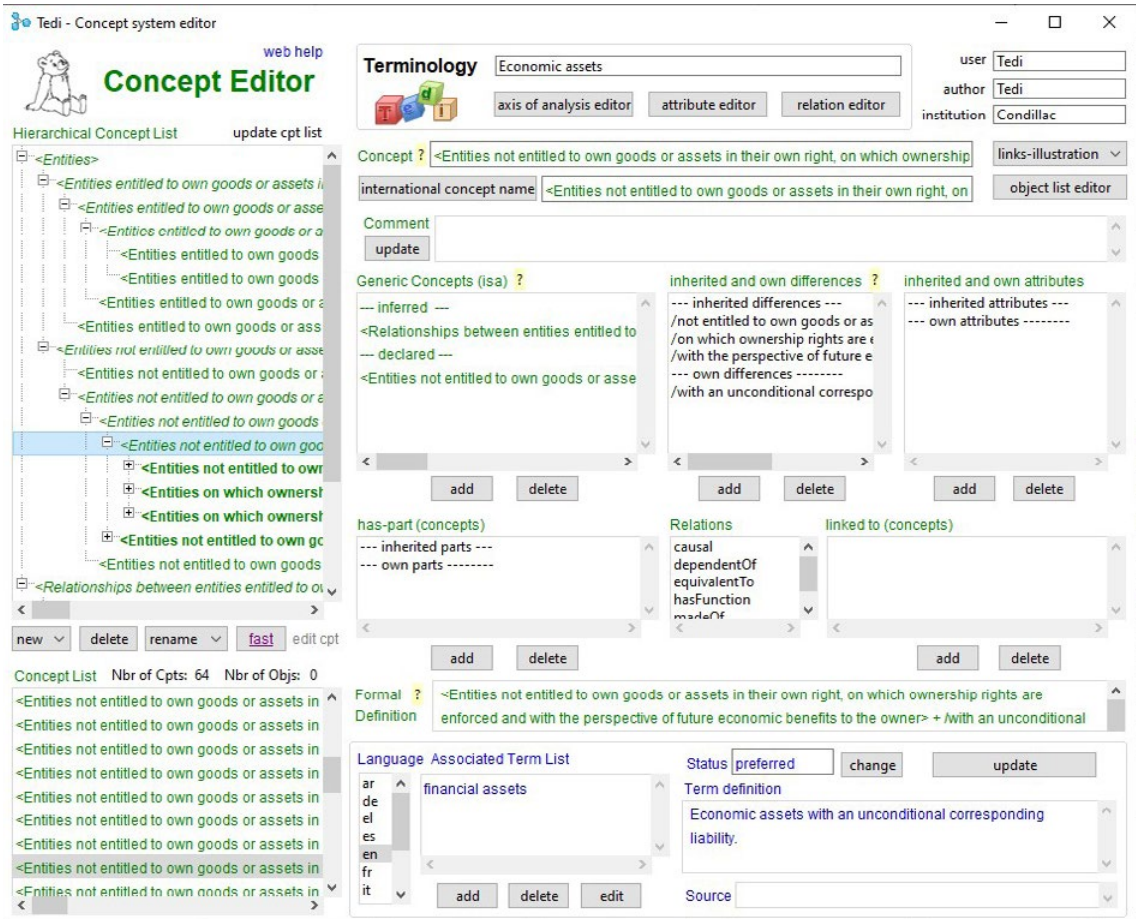

Figure 2: Concept Editor in TEDI

closest hypernym and the specific difference. In our example, the concept mentioned is denoted by the term "financial assets", whose definition in natural language is "economic assets with an unconditional corresponding liability".

The ontology built using this method is exported from TEDI to CMapTools as a concept map that shows all identified generic relations among concepts, and from CMapTools to PDF, in order to be submitted to the experts. The detail view (figure 3) shows, at each level, the essential characteristic (specific difference) with which the corresponding concept is built. Certain combinations of characteristics build concepts that are not relevant for the domain under scrutiny. In figure 3 the captions in black (on the right side) show concepts irrelevant for the balance of payments. Moreover, not all concepts built are named in natural language with a term: for example, there is no term to denote any of the intermediate concepts built to produce, from the generic concept <Entities>, the specific concept labelled <A>.

The linguistic dimension is edited in the Term Editor (see figure 4). In our example, we can see different information entered based on the terms extracted in English from IMF (2009): term status, part of speech, gender, as well as the automatically computed hypernym and hyponyms. However, the linguistic dimension is not part of the material sent to the experts for validation. The experts at two central banks,

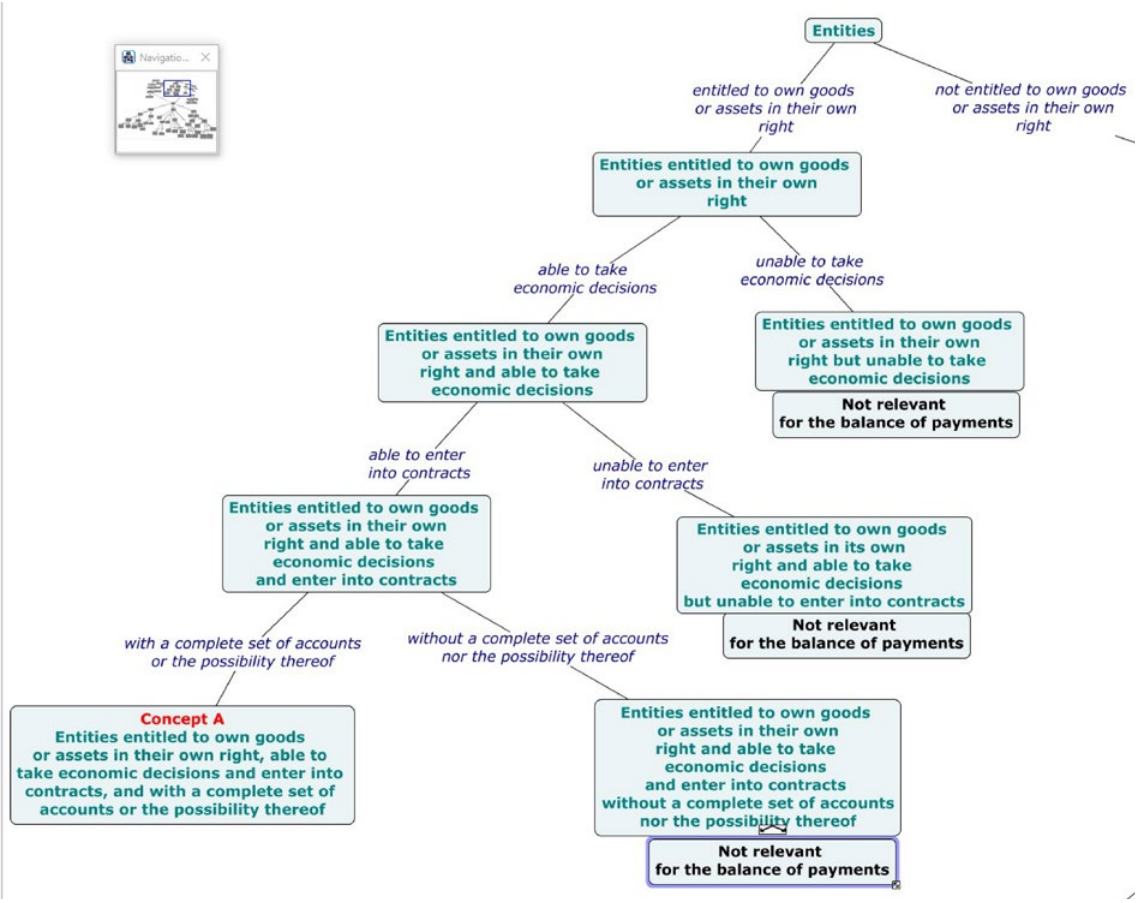

Figure 3: Detail view of the concept map showing the specific differences used to build the concepts

namely the National Bank of Belgium and the Swiss National Bank (see section 7.), receive the concept map and are asked to name in their own language (Dutch, French and German) a selection of 16 concepts marked from A to P. The underlying idea is that if the experts are able to name most of these concepts in their own language, the micro-ontology and consequently the methodology applied are validated.

5.2. Results obtained

The result of the validation process is satisfactory: 14 to 15 concepts out of 16 have been correctly identified (see figure 5). Experts were able to name most concepts in their own language. However, they had some difficulties with identifying certain concepts. (Interestingly, the difficulties did not concern the same concepts.) This good result is certainly due to the fact that IMF (2009) is a reference manual containing numerous definitions that offer characteristics often available for use in building Aristotelian concepts. With this methodology for ontology building, we can "speak the language of experts".

Nevertheless, several aspects need to be corrected or analysed in greater detail. First, the interaction with experts has shown the importance of correctly naming the upper categories: "Entities" was

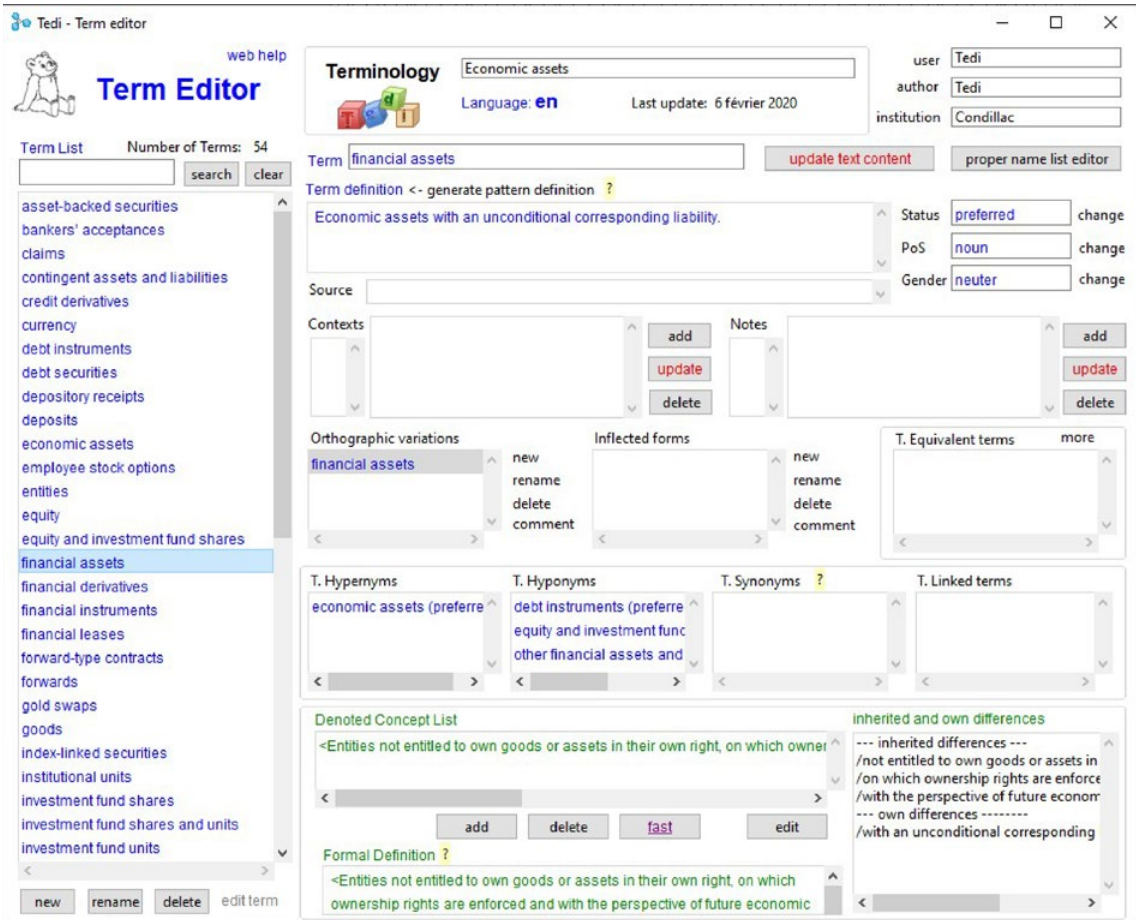

Figure 4 : Entry of the linguistic data in the Term Editor

Feedback sur la micro-ontologie des actifs économiques

Feedback on the micro-ontology concerning economic assets

Nom / Name: Karolien De Cooman ..... **Organisation**: National Bank of Belgium ..... **Date:** 10/02/2020 .....

Concept	Avez-vous pu identifier le concept ? Could you identify the concept?			Terme néerlandais dénotant le concept à la BNB Dutch term used at the BNB to denote the concept	Remarques (p.ex. terme correspondant dans le MBP6) Notes (e.g. corresponding BPM6 term)
	Oui, facilement Yes, easily	Oui, difficilement Yes, not easily	Non No		
A	x			Institutionele eenheid	Institutional unit
B			x		The description is not very clear.
C	x			Financiële instrumenten	Financial instruments
D	x			Financiële claims	Financial claims
E	x			Financiële activa	Financial assets
F	x			Eigen vermogen en aandelen van beleggingsfondsen	Equity and investment fund shares
G	x			Schuldinstrumenten	Debt instruments
H	x			Aandelen van beleggingsfondsen	Investment fund shares
I	x			Eigen vermogen	Equity
J	x			Financiële derivaten	Financial derivatives
K	x			Terugkoopovereenkomst van effecten	Securities repurchase agreement
L	x			Effecten gedekt door activa	Asset-backed securities
M	x			Overdraagbare deposito's	Transferable deposits
N	x			Personeelsopties	Employee stock options
O	x			Opties	Options
P	x			Termijncontracten	Forward-type contracts

Feedback - Micro-ontology on economic assets **Stéphane Carsenty (USMB/SNB)** **04/02/20**

Figure 5: Identification of concepts by experts – example of a feedback form

used as an upper category in the ontology for both humans and things, and it was unanimously criticised by experts as confusing. They give their preference to "Things" – a term that is indeed quite common in ontology building … even when modelling human beings!

Second, the ontology was text-based (viz. on IMF [2009]). Although the text selected as a corpus is rich in linguistic markers of relations, the ontology contained errors, which the experts have identified. These errors are due to the fact that not every conceptual relation is expressed with linguistic means. The quality of an ontology whose development is based on texts depends directly on the ability of its author to access extralinguistic knowledge. Because terminology has two dimensions, "the extralinguistic perspective – the study of the conceptual relations that obviously interact intra- and/or interlinguistically" is essential for the understanding of "the relation between that which is denominated and its denomination" – a relation which "is also at the core of all research based on the construction of ontologies" (Costa 2006: 80–81). For that purpose, interactions with experts are indispensable.

Another point stresses the necessity of a deepened study of the extralinguistic perspective. A subtlety that could not be detected in English by a non-expert has been identified thanks to experts: the term "assets" @EN has two equivalents @DE: "Aktiven" and "Vermögenswerte", which do not denote the same concept. A more precise conceptualisation will be needed in the future.

Moreover, an expert remarked that, depending on circumstances, certain "things" can be regarded in the BPIIP as "institutional units" although they do not possess all characteristics listed as essential

for building the corresponding concept. Indeed, IMF (2009) gives the statisticians basic principles for linking economic objects (observed and captured by the statistical aggregates) and accounts. But it is *not* ontology based. It will be necessary to analyse this aspect more precisely in the future.

Finally, an expert has noted that some non-hierarchical (viz. non-generic) relations among concepts should also be modelled. This should also be examined in the future. As mentioned, modelling these relations is possible in TEDI.

6. Preliminary conclusions

Constructing ontologies is a time-consuming process with several iterations of exchanges with experts. It can facilitate knowledge transfer and sharing. The first sketch of micro-ontology of the economic assets created in TEDI and submitted to the experts was elaborated in a short period of time, which has not allowed all the necessary interactions. Nevertheless, it has permitted to model in a satisfying way the concepts and relationships present in this portion of the balance of payments. Guided by the essential characteristics collected in the reference manual, the experts were able to identify most of the concepts and to name them in their own language. Ontology building is thus a valid method for identifying terms and finding equivalents in different languages. Moreover, it makes knowledge transmission to non-experts easier.

However, the use of this approach in a socially constructed domain with non-material objects like the balance of payments raises questions. As briefly mentioned, certain things can be considered as subsumed under a given concept without owning all essential characteristics identified as necessary. This phenomenon, as well as non-generic relationships existing in the domain, will have to be further analysed in the future.

7. Special thanks

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Hildegard Muff, Balance of Payments specialist at the Swiss National Bank

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