

# Representing Money as a Pure Commodity in Ontologies

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## Abstract

Money remains an elusive entity, notwithstanding its paramount importance in the ontology of goods and services. In this paper we focus on the “pure commodity theory of money”, which has been recently developed in philosophy and which says that money is in nature a commodity that is a potential medium of exchange shared by members of a group. We develop the idea that the pure commodity theory of money can serve as a theoretical underpinning of a general ontological analysis of money and a comprehensive ontology of economic reality, because it is impervious to the objections to the standard commodity theory and it can even accommodate the credit theory of money as the main contender of the commodity theory. To illustrate this idea, we explore a way of providing an ontological representation of money as a pure commodity in accordance with the upper ontology Basic Formal Ontology (BFO).

## Keywords

money, commodity, medium of exchange, goods, service, economic exchange, Basic Formal Ontology (BFO)

## 1. Introduction

Money has been pervasive throughout human history, especially in modern society. It has been an object of active inquiry in philosophy, economics and formal ontology. In particular, there is a growing demand for representing money in the ontology of economic reality, as it is one of the basic economic entities — alongside goods, services and economic exchanges. The nature of money nonetheless remains nebulous owing to its diverse ontological characteristics.

In this paper we focus on the recently developed, philosophical theory of money that is called the “pure commodity theory of money” [1]. The cardinal idea of this theory is that money is, by its own nature, a commodity that is a potential medium of exchange which is shared by members of a certain group. As we will see in detail below, the pure commodity theory of money is immune to the kind of objections that the standard commodity theory typically suffers and it can even accommodate the credit theory as the prominent opponent of the commodity theory. We put forward the idea that the pure commodity theory has the potential to theoretically underwrite a general ontological representation of money and a full-fledged ontology of economic reality.

The objective of this paper is to take the initial steps towards an ontology of money that is theoretically anchored to the pure commodity theory of money. For this purpose, we will begin by adumbrating the pure commodity theory of money in Section 2. In particular, we will explain the meanings of the term “commodity” and “potential medium of exchange” that are central to the pure commodity theory. In Section 3, we will illustrate the applicability of the pure commodity theory to ontology development by considering how the notions of commodity and potential medium of exchange figuring in the pure commodity theory can be represented in compliance with the upper ontology Basic Formal Ontology (BFO) [2, 3]. In Section 4, we will briefly discuss related work on money in formal ontology, in connection with the pure commodity theory. In Section 5, we will conclude the paper with some remarks on future work. For the sake of simplicity, we will refer only to page numbers in citing Massin’s [1] work about the pure commodity theory of money.

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## 2. The pure commodity theory of money: An overview

To present a general overview of the pure commodity theory of money, we will first explain the standard commodity theory of money and the typical objections to it (Section 2.1). Then, we will articulate the pure commodity theory, especially the notions of commodity and potential medium of exchange (Section 2.2). Finally, we will provide some main reasons to think that the pure commodity theory can serve to theoretically undergird an ontology of money (Section 2.3).

### 2.1. The standard commodity theory of money and its problems

In philosophy and economics, there is a debate over the nature of money between the commodity theory and the credit theory [4]. On the one hand, the commodity theory says that money is a commodity to be used as a medium of exchange. This traditional theory of money has been espoused by many philosophers and classical economists [5, 6], but it is also vulnerable to severe criticism (as we will explain shortly). On the other hand, the credit theory says that money is a kind of credit or claim [7, 8, 9]. This view has been supported by modern economists [10, 11] with an emphasis on the role of money in modern monetary systems, for example on the fact that the value of money is typically guaranteed by states.

According to Massin [1], the standard commodity theory of money can be formulated as follows:

#### **Standard commodity theory of money**

$x$  is money relative a group  $G$  iff:

(SC1) *Function*:  $x$  is a commodity shared as a means of exchange among members of  $G$ .

(SC2) *Origin*:  $x$  came to be accepted as a means of exchange spontaneously from a situation of barter in which  $x$  was a commodity among others.

(SC3) *Commodity*: a commodity is an entity:

(SC3.1) that is tangible;

(SC3.2) which has use value independent of its exchange value.

(pp. 2-3, with notational modifications for readability)

(SC1)-(SC3) can be illuminated as follows. Firstly, (SC1) is the kernel of the standard commodity theory and it is intimately connected with the commodity theorist's argument that money consists in solving the problem of "double coincidence of wants" [12]. This problem is, roughly, that exchange in a barter economy requires a double coincidence of wants (i.e., the situation in which one economic agent has what the other wants and *vice versa*), but its absence prevents the optimal distribution of commodities (synonyms: "goods") among all the agents.

Secondly, the term "spontaneously" in (SC2) means: "without any central intervention – where through coercion or incentivization – and without collective intentionality" (pp. 3-4). To elucidate this point, consider for instance Searle's [13] initial account of money, according to which a physical object becomes money in virtue of being assigned the "status function" of being a medium of exchange through collective intentionality (see e.g., [14, 15, 16, 17] for clarification and criticism). Searle's account is a commodity theory (comprising the standard commodity theory) because it says that money is in nature a commodity used as a means of exchange (SC1), although it is not a standard commodity theory because, for Searle, money comes to be accepted as a means of exchange through collective intentionality rather than spontaneously – which contradicts (SC2).

Thirdly, the term "tangible entity" in (SC3.1) refers to "physical or material entities: entities that exist in time and in space" (p. 4). Moreover, (SC3.2) implies that any commodity must have an independent use value before being used as a medium of exchange and thereby becoming money: for example, food has the use value of being used to satisfy nutritional needs. (SC3) follows from (SC2) and the natural assumption that, being candidates for being money, commodities exchanged in a barter economy are typically tangible entities that have an independent use value.

The standard commodity theory of money has been regarded as problematic, not least because (SC2) and (SC3) can be liable to criticism. Concerning (SC2), it has been argued to conflict with the historical

and anthropological fact that barter economy systems (posited by the standard commodity theory) have been rarely, if ever, observed in human history [7, 8, 9][18, ch. 3]. Concerning (SC3.1), intangible money constitutes a counterexample to this thesis [19, 20], as it is well illustrated by electronic money such as bitcoins [21] and cryptocurrency [22] (which should not be conflated with electronic records, though [14]). Concerning (SC3.2), it can be invalidated by the existence of fiat money: money that is introduced only as a medium of exchange and thus devoid of any independent use value.

## 2.2. Money as a commodity that is a shared, potential medium of exchange

The pure commodity theory of money is a refined version of the commodity theory that intends to be more defensible than the standard commodity theory. More concretely, the pure commodity theory abandons (SC2) and (SC3). As for (SC2), there is no essentiality of origin for money because money (serving as a medium of exchange) could have come into being in several ways, such as spontaneously (following the standard commodity theory) or through collective intentionality (following Searle).

As for (SC3), it can be proposed that, contrary to (SC3.1), the notion of commodity (or goods) should be characterized as an “exchangeable continuant” (in the sense of the term “continuant” as used in formal ontology). Consequently, intangible or immaterial continuants can be counted as commodities, as well as tangible continuants. To borrow Massin’s [1] examples, immaterial commodities include promissory claims, softwares and the right to access a service. Moreover, the view of commodities as exchangeable continuants justifies rejecting (SC3.2) because it leaves open the possibility that there are commodities (e.g., fiat money) that lack any use value which is independent of exchange value.

Here it is important to emphasize that immaterial commodities should be sharply distinguished from services [23, 24]. While commodities are exchangeable continuants, services are “exchangeable occurrents” (in the sense of the term “occurrent” as used in formal ontology). For instance, a concert ticket gives you the right (immaterial continuant) to go to the concert, but this right is different from a concert experience service (occurrent). We can also remark that (SC3.1) may be traditionally supported by the misunderstanding of the nature of exchanges of commodities and (the transfer of) ownership of commodities (see [25, 26] for details).

All these considerations lead to the following formulation of the pure commodity theory of money:

### Pure commodity theory of money

$x$  is money relative a group  $G$  iff:

(PC1)  $x$  is a commodity.

(PC2)  $x$  is a potential medium of shared by members of  $G$ .

(PC3)  $x$  enables those agents to solve the problem of double coincidence of wants.

(p. 14, with notational modifications for readability)

where the term “commodity” is defined as “an exchangeable continuant” and the term “potential medium of exchange” is defined as follows:

### Potential medium of exchange

$x$  is a (potential) medium of exchange shared by members of a group  $G$  iff each member of  $G$  knows that, if he wanted to, and had some  $y$ , he could, with other members of  $G$ :

1. Acquire  $x$  in exchange for some  $y$  with the intention of re-exchanging  $x$  for some  $z$ .
2. Subsequently acquire  $z$  in exchange for  $x$ .

(p. 14, with notational modifications for readability)

Several clarificatory remarks are in order. Firstly, the pure commodity theory characterizes money in terms of the notion of *potential* medium of exchange to accommodate the fact that commodities can qualify as media of exchange even if they never actually mediate exchanges.

Secondly, the definition of potential medium of exchange involves the agent’s knowledge (“each member of  $G$  knows that”). For one thing, the agent’s ignorance of a commodity being a potential medium of exchange prevents the agent from solving the problem of the double coincidence of wants

(the resolving of which constitutes a chief motivation of the commodity theory in general). For another, reference to knowledge in the definition helps to highlight that a medium of exchange is shared by all the agents who have that piece of knowledge (which is not necessarily common knowledge, though).

Thirdly, (PC3) is postulated in order to deal with the counterexamples to a simpler but naïve theory of money that is based on the pair of (PC1) and (PC2), but not on (PC3). For example, financial assets could be potential media of exchange, inasmuch as (PC1) and (PC2) are concerned. But according to the pure commodity theory (including (PC3)), they qualify as money, provided that they allow the traders buying and selling them to address the problem of the double coincidence of wants.

### **2.3. The pure commodity theory as a theoretical underpinning of an ontology of money**

We think that the pure commodity theory of money can be useful in forming a theoretical basis of an ontology of money for several reasons. Firstly, it is general enough to be adaptable to different ontologies of money in different domains, especially when they are developed within different foundational frameworks (see Section 4 for examples). The pure commodity theory primarily rests on the notions that are widely used in formal ontology. For instance, it takes commodities (or goods) to be a subtype of continuants, which are accepted in many major upper ontologies (see Section 3 for illustration with the example of BFO).

Secondly, the pure commodity theory is comprehensive enough to explain other functions and views of money. In formal ontology, for instance, being a store of value and being a unit of account are commonly cited as criteria for being money, as well as being a medium of exchange (see e.g., [27, 28]). According to the pure commodity theory, these two functions of money can be derived from the definition of money as a commodity to be used as a medium of exchange. Money can be used as a store of value because at least some, if not all, of the exchange value of money (serving as a medium of exchange) must be kept between the two exchanges. Money can be used as a unit of account because the value of a given exchanged entity can be evaluated in terms of the amount of money that serves as a medium of exchange.

For another example, the pure commodity theory can even accommodate the credit theory as a prominent challenger of the commodity theory. Massin [1] examines two main versions of the credit theory, the more tenable of which is the “transferable claim theory” in his terms and says that money is a transferable claim. In his view, the transferable claim theory is a version of the pure commodity theory because transferable claims can be considered as continuants to be used as media of exchange (recall that claims are intangible or immaterial continuants; see Section 2.2). Given this argument, the pure commodity theory can be expected to serve as a point of reference for comparing and integrating ontologies of money that are grounded in the commodity theory and/or the credit theory.

## **3. Representing money as a pure commodity in ontologies**

We propounded the idea that the pure commodity theory of money is of potential utility for the development of a general ontology of money. To illustrate this proposal, we will consider how the pure commodity theory can be formalized in accordance with the upper ontology Basic Formal Ontology (BFO) [2, 3]. In Section 3.1, we will present the basic structure of BFO as a preliminary. In Section 3.2, we will sketch a way of representing the view of money as a pure commodity within the BFO framework.

We choose BFO as a case study for several reasons. For one thing, the pure commodity theory can be relatively easily adapted for BFO among major upper ontologies and this can mesh with our purpose to illustrate the pure commodity theory in the context of formal ontology. For another, a BFO-compliant ontological characterization of money (e.g., [29]) may remain underexplored, for example as compared to an ontology of money [27, 30, 31] developed in alignment with the Unified Foundational Ontology (UFO) [32, 33] (see Section 4 for details on related work).

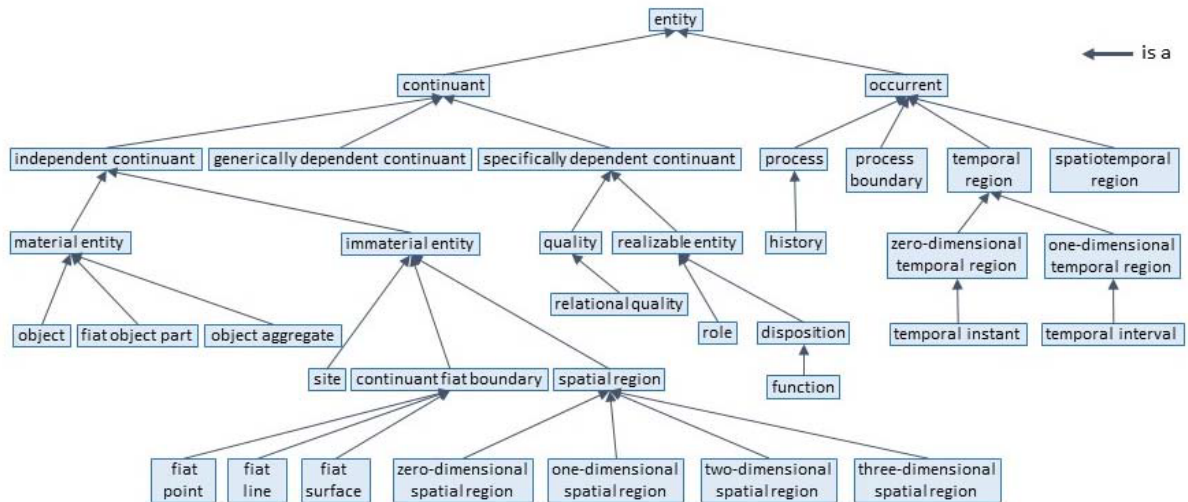


Figure 1: BFO's *is\_a* hierarchy under the ISO standard (extracted from [34])

### 3.1. Preliminaries: Basic Formal Ontology (BFO)

Figure 1 presents BFO's *is\_a* hierarchy under the ISO standard (ISO/IEC 21838). We will explain selected BFO categories that are relevant to our purpose of outlining an ontological analysis of the pure commodity theory. BFO includes the top-level distinction between continuants (which persist through time) and occurrents (which unfold themselves in time).

In the category of continuant, independent continuants include material entities such as fruits, people and tangible money (e.g., US dollar bills). They also include immaterial entities, which in turn include sites. A site in BFO is: "An immaterial entity in which objects such as molecules of air or organisms can be contained" [2, p. 184] (see [35] for more thoughts). Examples include my nasal cavity and the hold of a ship.

A generically dependent continuant is a continuant that depends (existentially) on one or other independent continuant and can "migrate" from one bearer to another through a process of copying. Intuitively speaking, it is a "copyable pattern". Examples include pdf files (which can be moved from one storage device to another) and novels (which can have multiple printed copies). In ontological terms, electronic money is typically classified as a generically dependent continuant (cf. [28, 29]; see Section 4).

A specifically dependent continuant is a continuant that depends (existentially) on at least one independent continuant. Examples include qualities such as my height and realizable entities such as dispositions and roles (see [36, 37, 38] for careful thoughts on realizable entities in BFO).

A disposition in BFO is a realizable entity that exists because of certain features of the physical makeup of the independent continuant that is its bearer. It is an "internally grounded realizable entity" in the sense that, if a BFO:disposition ceases to exist, then the physical makeup of the bearer is changed (see [36, 37] for discussion about the notion of being "internally (or externally) grounded" of realizable entities in BFO). Examples include the fragility of a glass and the flammability of a match.

A role in BFO is a realizable entity that (1) exists because the bearer is in some special physical, social, or institutional set of circumstances in which the bearer does not have to be (optionality), and (2) is not such that, if this realizable entity ceases to exist, then the physical make-up of the bearer is changed (external grounding). Briefly, a BFO:role is an externally grounded and optional realizable entity. Examples include the role of being a student and the role by a stone of marking a boundary.

In the category of occurrent, a process in an occurrent that exists in time by occurring, i.e., by having (proper) temporal parts, and which depends on at least one independent continuant as participant. Examples include a process of using something as a medium of exchange.

## 3.2. Formalizing the pure commodity theory of money: An outline

We will lay out an a BFO-compliant ontological characterization of the pure commodity theory of money. In particular, we will focus on (PC1) (together with the definition of commodity as an exchangeable continuant) and (PC2), while leaving (PC3) for future work owing to the complexity of the formulation of the problem of the double coincidence of wants. In addition, we will consider the formalization in the Web Ontology Language (OWL) (partially adhering to the Manchester Syntax) because of the practical utility of the OWL representation in ontology development.

### 3.2.1. Formalizing “commodity as an exchangeable continuant”

Firstly, regarding the view of commodities as exchangeable continuants, let us begin by presenting Otte et al.’s [39] BFO-compliant definition of commodity that is based on the notion of “commodity role”, which is in turn based on the notions of “economic good role” and “act of appraisal”:

act of appraisal =<sub>def.</sub> A process where an agent evaluates an entity, for example, to access its monetary value.

economic good role =<sub>def.</sub> A role that inheres in some material entity and is realized in some act of appraisal.

commodity role =<sub>def.</sub> An economic good role that inheres in some material entity that is not an object and is realized in some act of appraisal.

commodity =<sub>def.</sub> A material entity that bears a commodity role.

[39, p. 191]

On the one hand, Otte et al.’s definition of the term “commodity” may be too limited to capture the view of commodities as exchangeable continuants that operates in the pure commodity theory. For instance, the notion of act of appraisal (on which this definition rests) can involve the (possible) assessment of *monetary* value, but the pure commodity theory consists in explicating money in terms of the notion of commodity. Moreover, according to the definition of commodity under examination, any commodity is a material entity (to wit, a BFO:material entity which is not an BFO:object, according to the definition of commodity role). But this contradicts the pure common theory’s view that commodities should include not only material entities but also immaterial entities (see Section 2.2).

On the other hand, it is plausible to characterize the idea of commodity as an exchangeable continuant in terms of the BFO notion of role – in harmony with Otte et al.’s ontological approach to commodities – as a material entity becomes a commodity when it exists in some special (to wit, socio-economic) context in which it does not have to be (optionality) and ceasing to be a commodity does not necessarily involve the change in the physical make-up of the material entity (external grounding).

Therefore, we will provide an alternative definition of the term “commodity role” that can serve to articulate the notion of commodity as an exchangeable continuant. To achieve this aim, we will direct attention to the BFO-aligned Ontology of Commercial Exchange (OCE) [40, 41], especially the OCE term “act of commercial exchange” [41, p. 4], while following the general principle of the reuse of existing ontologies in ontology development. We can define the term “commodity role” in terms of the OCE notion of act of commercial exchange and present an associated axiom using the *realized\_in* relation (BFO\_0000054), as follows:

commodity role =<sub>def.</sub> A role of being the object of a commercial exchange.

*Commodity role* subClassOf (*realized\_in* some *Act of commercial exchange*)

We note that we will henceforth employ the term “commodity role” as defined in the foregoing, unless otherwise specified. We also remark that, in order for the proposed notion of commodity role to be well-suited to the pure commodity theory, the definition of the OCE term “act of commercial exchange” may require revision, as it could render the definition of money circular owing to its appeal to the notion of “portion of cash” (see e.g., [41, p. 3]) borrowed from the BFO-compliant Common Core Ontologies (CCO) [42]. Addressing this task will also help to elaborate the notion of “object of commercial exchange”. These issues are left for future work.

We will now define the term “commodity” in terms of our notion of commodity role. Recall that, unlike the standard commodity theory, the pure commodity theory intends to accommodate immaterial commodities as well as material ones. Whereas material commodities can naturally fall into the BFO category of material entity, there are at least two categories which are subtypes of the BFO category of continuant and into which immaterial commodities can fall: those of site and generically dependent continuant. On the one hand, we can characterize commodities that are sites (e.g., the hold of a ship) in terms of bearing a commodity role because sites can bear specifically dependent continuants (but see [43] for the view that the current BFO specifications of dispositions and roles should be generalized to apply to e.g., sites).

On the other hand, we cannot provide a parallel analysis for commodities that are generically dependent continuants (e.g., the right to access a service) because no generically dependent continuant can *bear* any specifically dependent continuants. However, as BFO offers the relation of “concretizes” (RO\_0000059) between a specifically dependent continuant (or a process) and a generically dependent continuant, we may be able to specify commodities that are generically dependent continuant in terms of *being concretized as* (RO\_0000058) some commodity role. In effect, the view of commodities that are generically dependent continuants as concretized as some commodity role(s) can be compatible with the explanation that the credit theory of money is a variant of the pure commodity theory (see Section 2.3), as (transferable) claims can be generally considered as generically dependent continuants.

All these considerations can lead to the following ontological characterization of the notions of commodity and money figuring in the pure commodity theory (PC1), using the *has\_role* (RO\_0000087) and *is\_concretized\_as* (RO\_0000058) relations:

commodity =<sub>def.</sub> A continuant that can be the object of commercial exchange.

*Commodity* subClassOf (*Continuant* and [(*has\_role* some *Commodity role*) or (*is\_concretized\_as* some *Commodity role*)])

*Money* subClassOf *Commodity*

### 3.2.2. Formalizing “potential medium of exchange”

Let us turn to formalizing (PC2) or more specifically the definition of the term “potential medium of exchange”, which will be reintroduced as a reminder below:

#### **Potential medium of exchange**

$x$  is a (potential) medium of exchange shared by members of a group  $G$  iff each member of  $G$  knows that, if he wanted to, and had some  $y$ , he could, with other members of  $G$ :

1. Acquire  $x$  in exchange for some  $y$  with the intention of re-exchanging  $x$  for some  $z$ .
2. Subsequently acquire  $z$  in exchange for  $x$ .

First of all, we emphasize that the notion of potential medium of exchange aims to capture a “modal or dispositional sense” of the term “medium”: “something that can mediate, even when it is not actively doing so” (p. 11). This dispositional understanding of medium of exchange is reflected in the following part of the definition of potential medium of exchange: “*if* [each member of  $G$ ] *wanted* to, and *had* some  $y$ , *he could*” (with our emphasis). In light of this observation, we propose the term “disposition to use as a shared medium of exchange” as follows:

disposition to use as a shared medium of exchange =<sub>def.</sub> A disposition of a member of a group (i) to acquire a continuant  $x$  for a continuant  $y$  with the intention of re-exchanging  $x$  for a continuant  $z$  and (ii) to subsequently acquire  $z$  in exchange for  $x$ , with other members of the group, if the bearer wants to and has  $y$ .

Two clarifying comments will be provided. Firstly, this definition is a direct adaptation of the definition of potential medium of exchange and it may be further analyzed under some auxiliary assumptions. For instance, assuming that intention is a kind of disposition [44], the disposition to use as a shared medium of exchange may be articulated in terms of three dispositions: at first approximation, the disposition to acquire  $x$  for  $y$  (with other members of a group to which the bearer belongs – to be omitted for simplicity), the intention (which is a disposition) to re-exchange  $y$  for  $z$  and the disposition to acquire  $z$  in exchange. This line of study will not be pursued here, though, partly because it will warrant representing the complex relationships between dispositions.

Secondly, although the notion of disposition to use as a shared medium of exchange may defy straightforward axiomatization, we can create an OWL statement that any disposition to use as a shared medium of exchange is borne only by some agent that is a member of some group, by using the *inheres\_in* (RO\_000052) and *member\_part\_of\_at\_some\_time* (BFO\_0000129) relations as well as the CCO classes *Agent* and *Group of agents* (see e.g., [41, p. 2]), as follows:

*Disposition to use as a shared medium of exchange* subClassOf (*inheres\_in* only [*Agent* and (*member\_part\_of\_at\_some\_time* some *Group of agents*)])

Next, as we highlighted in Section 2.2, the definition of potential medium of exchange involves the agent's knowledge. Knowledge is notoriously difficult to analyze from a philosophical standpoint, since it may resist reduction to the orthodox notion of "justified true belief" (see e.g., [45]). In line with the reuse principle in ontology development, we borrow here the class *Knowledge* from the BFO-compliant Behaviour Change Intervention Ontology (BCIO) [46, 47], which defines it as: "A mental disposition to understand the nature of the world, or a specific aspect of the world, that corresponds to the actual state of the world and is acquired through experience or learning."

One way of representing the epistemic dimension of the notion of potential medium of exchange may be to think that any disposition to use as a shared medium of exchange is the object of some knowledge – which is a kind of disposition. To formalize this statement, it will be useful to borrow the class *Information content entity* (IAO\_0000030) and the *denoted\_by* relation (IAO\_0000235) from the BFO-compliant Information Artifact Ontology (IAO) [48], as the notion of information content entity can be used to analyze the content of mental attitudes (cf. [49]). By using the *is\_concretized\_as* relation as well (see Section 3.2.1), we can propose the following OWL axiom:

*Disposition to use as a shared medium of exchange* subClassOf (*denoted\_by* some [*Information content entity* and (*is\_concretized\_as* some *Knowledge*)])<sup>1</sup>

Finally, the pure commodity theory implies that any money can be used as a medium of exchange shared by members of a group. One way to axiomatize this idea may be to introduce the term "shared medium of exchange role". For an entity can be a shared medium of exchange when it is in some special set of circumstances – economic ones in particular – in which it does not have to be (optionality) and ceasing to be a shared medium of exchange does not necessarily involve the change of the entity's physical makeup (external grounding). This newly introduced kind of roles can be articulated in natural and formal languages as follows. In particular, we can specify it logically, by using the *realized\_in* (see Section 3.2.1) and *realizes* (BFO\_0000055) relations, in such a way that any shared medium of exchange role is realized only in some process that is a realization of some disposition to use as a shared medium of exchange:

<sup>1</sup>According to Barton et al. [49], an information content entity relevant to a "dispositional belief" [44] is concretized as part of a "categorical basis" [37, 50] of the dispositional belief. From the viewpoint of this proposal, this axiom may be seen as a simplified and approximate ontological representation of the relationship between information content entities and knowledge, since both dispositional belief and knowledge fall into the BFO category of disposition.

shared medium of exchange role =<sub>def.</sub> A role to be used as a medium of exchange shared by members of a group.

*Shared medium of exchange role* subClassOf (*realized\_in* only [*realizes* some *Disposition to use as a shared medium of exchange*])

We can now formalize (PC2) with recourse to the notion of shared medium of exchange role as well as the *has\_role* and *is\_concretized\_as* relations (see Section 3.2.1) as follows:

*Money* subClassOf [(*has\_role* some *Shared medium of exchange role*) or (*is\_concretized\_as* some *Shared medium of exchange role*)]

## 4. Related work on money in formal ontology

There is a huge body of literature on the nature of money in philosophy, economics and formal ontology (see e.g., [4] for an overview). Here we will briefly discuss several accounts of money in formal ontology that are foundationally well-founded.

Andersson & Paul [28] discuss money in terms of the “three level model” consisting of the “physical level”, “social level” and “information level”, as “the notion of money is somehow related to all of them” (ibid., p. 2). To borrow their example, a euro bill is a material entity at the physical level, it also lies at the information level, as it “carry[s] information that expresses an economic value” (ibid., pp. 2-3); and it may be said to represent a social debt, which comes into being a process of promising and exists on the social level.

From the standpoint of the pure commodity theory, we can interpret money at the physical level and money at the informational level approximately as material and immaterial commodities that serve as shared media of exchange, respectively. For that matter, Andersson & Paul argue that “electronic money [...] is a generically dependent continuant, in the terms of BFO” (ibid., p. 5), and this view is well compatible with our BFO-based characterization of the pure commodity theory (see Section 3.2). Moreover, money at the social level may be construed as money in the credit theory, which can be in turn construed as a specific kind of money in the pure commodity sense of the term (see Section 2.3).

Amaral et al. [27] (see also [30, 31]) develop a reference ontology of money that is grounded in the UFO upper ontology [32, 33]. At the core of their approach is the type *Monetary object type* whose instances are considered as money according to a certain “status function description” in their terms, which is a kind of “normative description” in UFO-C, namely a UFO modular ontology of social entities. Being inspired by Searle’s [13] notion of status function, their ontology of money might subscribe to the relevance of the origin of money to its nature, in contrast with the pure commodity theory (see Section 2.2).

Diller & Hogan [29] investigate a BFO-compliant ontological representation of money, while being motivated by the fact that money is a crucial economic determinant of health in the context of biomedical ontologies. Their key idea is that money is defined as a kind of “debt obligation”, which is in turn defined as a kind of “directive information entity” (IAO\_0000033) (which is a subtype of information content entity) as follows:

debt obligation =<sub>def.</sub> A directive information entity that prescribes that something will be transferred from some human or organization that is the bearer of a duty holder role to another human or organization that is the bearer of a claimant role.

money =<sub>def.</sub> A debt obligation between two parties that has part a scalar value specification and whose concretizations indicate that their bearers can be used in a financial transaction or payment of debt, or as a measure of the value of some entity in a financial valuation process or prospective financial valuation process.

Since it relies on the notions of claim and obligation, Diller & Hogan’s definition of money is predicated upon the credit theory of money – to wit, the transferable claim theory – which is arguably a version of the pure commodity theory: debt obligations constitute one form of money (which is a pure commodity), but not all forms of money are debt obligations (see Section 2.3). We hypothesize that this definition of money as a debt obligation can be integrated into our BFO-based analysis of money, further exploration being left for future work. For example, money in Diller & Hogan’s definition may be understood within our approach as a special kind of directive information entity (which is a kind of generically dependent continuant) that is concretized both as some commodity role and as some shared medium of exchange role (see Section 3.2; and Section 5 for a pointer to this line of inquiry).

Finally, Mizoguchi et al. [51] provide an ontological analysis of money. Its basic idea is to distinguish between “monetary role” and “money” such that the former is a social role that is played by a physical object in the context of an economic system and the latter is an extrinsic property of an agent that owns a “monetary object” (e.g., ten euros in currency) which plays some monetary role. From a theoretical point of view, their analysis may be seen as a version of the “hybrid theory” of money which purports to encompass both the commodity theory and the credit theory (see e.g., [19, 20, 22, 52]).

We think however that the hybrid theory of money is less compelling than the pure commodity theory owing to its problematically disjunctive definition of money – although a reinterpretation of the former within the framework of the latter is deferred to future work. For instance, according to Mizoguchi et al., being a unit of account is more fundamental than being a medium of exchange, as the former is associated with a monetary role and the latter is with a monetary object. But we argued in Section 2.3 that money’s function of being a unit of account is a derivative of money being in nature a medium of exchange. For another example, they maintain that a monetary role depends existentially on the trust of a community and on the guarantee provided by the community. In our view, however, for a medium of exchange to be shared by members of a group, it is not required that this knowledge should be common to all the agents of the group – hence the absence of a fundamental connection between the trust of a group and the nature of money (see Section 2.2).

## 5. Conclusion

In this paper we embarked upon a project to develop an ontology of money that is theoretically underpinned by the pure commodity theory of money in philosophy: money is in nature a commodity to serve as a medium of exchange shared by member of a group. To illustrate this idea, we presented a set of key terms and axioms with the aim of characterizing the pure commodity theory within the framework of the BFO upper ontology and the OWL representation. Examples of such key terms include “commodity role”, “disposition to use as a shared medium of exchange” and “shared medium of exchange role”.

In the future we plan to further develop this ontological account of money as a pure commodity in order to achieve the long-term goal of solidifying the foundations for a general ontology of economic reality. For instance, it will be necessary to ontologically deal with (PC3) in the pure commodity theory (in particular, the problem of double coincidence of wants) and other functions of money such as being a unit of account and being a store of value. For another example, when it comes to extending a BFO-based formalization of the pure commodity theory to the credit theory (see Section 4), it will be worth scrutinizing the BFO-compliant notion of “socio-legal generically dependent continuant” [53] in connection with the notions of commodity role and shared medium of exchange role, as this socio-legal entity was proposed to analyze claims and obligations and it is, by definition, concretized as some role of an agent (whether individual or collective).

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## Declaration on Generative AI

During the preparation of this work, the authors used ChatGPT in order to: Grammar and spelling check, Paraphrase and reword. After using this tool/service, the authors reviewed and edited the content as needed and take full responsibility for the publication's content.

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