

An Ontology of Production, Products and By-Products

1. Summary of the research plan

The starting hypothesis of this project is that there exists an important category of entities, widely used in the sciences but rarely studied as such, which we call *products and by-products*. This category includes cities, books, screwdrivers, waste, contractual claims, medicines, nations, pdf documents, money, laws, acquired skills and NFTs, but not revolutions, global warming, promises, atoms, tennis games, inflation, or eclipses. Though manifold, this category is unified by the fact that the entities in question are *continuant outcomes of human actions*. “Continuant” here contrasts with “occurrent”, and denotes entities that persist through time without having temporal parts (e.g., an earlier or later half). Continuants, so understood, include material objects but also capacities, legal obligations, or institutions, all of which arguably lack temporal parts. Not all continuants are products or by-products: fermions or wild animals, for example, need not be outcomes of human actions. The category of human products and by-products, while broad, is therefore not all-encompassing.

The general goal of this project is to develop and implement an ontology of human-made products and by-products. This ontology is relevant to many research areas, among them the theory of artifacts and actions, social ontology, economics, sociology, anthropology, education, archeology, and engineering, all of which are interested in specific kinds of products and by-products. One chief interest of our ontology of human products and by-products is to bring out that these seemingly disconnected research areas in effect share a common subject-matter. This insight can help to resolve data-fragmentation and incompatibilities which can arise when multiple research groups, responding to specific local needs, construct inconsistent ontologies concerning what is intuitively the same portion of reality. Such “information silos” result in a lack of accessibility and shareability of data, ultimately inhibiting scientific progress.

Unlike standard approaches in social ontology as well as the philosophy of action and artifacts, our approach to the ontology of human products and by-products de-emphasizes *intentions*, and instead assigns a more central role to *capacities*. In subproject 1, which focuses on the ontology of artifacts, we develop a conception of artifact-functions in terms of object-capacities rather than in terms of agent-intentions, thereby allowing for the possibility of artifacts that are used for purposes different from those for which they were originally intended. Subproject 2 focuses on the ontology of wealth and economic goods. The relation between wealth and capacities, we hypothesize, can be clarified by maintaining that capacities, though not themselves pieces of wealth, can nonetheless contribute to wealth by increasing the value of one’s goods. Both subprojects explore the complex interconnections between the capacities of agents and products. Of particular relevance to our project is the distinction between actual and potential capacities, which we take to be key to understanding both artifacts and wealth.

By focusing on the continuant outcomes of human productive actions and by shifting the emphasis away from intentions and towards capacities, we aim to develop an ontology for human products and by-products which includes material and immaterial (e.g., digital) artifacts, acquired capacities, as well as institutions. To achieve this aim, we proceed by investigating two distinct but overlapping classes of products and by-products: artifacts (subproject 1) and wealth (subproject 2). The insights reached in these two subprojects will be combined into a single overarching ontology of human products and by-products.

2. Research plan

2.1 Current state of research in the field. Within philosophy, human-made products and by-products have been investigated in the following areas of research: social ontology, the philosophy of artifacts and action, the metaphysics of dispositions and capacities, the philosophy of economics, and the development of formal and applied ontologies.

Social ontology. First, due to the influential hypothesis that social phenomena depend on collective intentionality, social ontology has largely focused on *intentional* social products (Tuomela & Miller, 1988; Tuomela, 1995, 2002; Gilbert, 1989, 1990; Searle, 1990, 1995, 2010; Bratman, 1992, 1993; Miller, 2001; Schmitt, 2003; Preyer, Hindriks & Chant, 2014; for overviews, see Jankovic & Ludwig 2018; Schweikard & Schmid, 2021), though some works in social ontology have stressed the importance of unintended social phenomena (e.g., Thomasson, 2003a, 2003b, 2005; Tieffenbach, 2010; Epstein, 2013). Second, due to Searle's influential distinction between *status-functions* and *non-status functions*, social ontology has mostly focused on *institutional* products (e.g., convention, money, marriages, law) at the expense of *artifacts* (e.g., chairs, tables, hammers, screwdrivers). Contrary to the functions assigned to artifacts, the functions assigned to institutional entities, Searle claims, are not based on their intrinsic physical features but on their being collectively recognized to have the status in question (Searle, 1995, 2010; Arp & Smith, 2008 implement this distinction within [BFO](#)). By contrast, in the philosophy of artifacts, the idea that the function of an artifact is determined by its intrinsic physical features has been challenged, suggesting that artifacts and institutional entities may instead occupy points along a spectrum of cases encompassing a variety of human-made products and by-products.

Philosophy of artifacts. In the philosophical literature on artifacts, the emphasis has been placed on the intentions and actions of agents who are responsible for the creation of artifacts. (We refer to such accounts as “author-intention-based approaches”, using the term, “author”, broadly to include makers, designers, producers, builders, etc., i.e., agents who are in some way responsible for the creation of an artifact or artifact kind.) According to prominent author-intention-based accounts, what kind of artifact is produced in a successful act of creation is taken to be either directly or indirectly determined by the content of the intention guiding the responsible agent, viz., their intention to produce a certain kind of thing by working in some fashion on some suitable matter (Baker, 2007; Dipert, 1993; Evnine, 2016; Hilpinen, 1992; Smith, 1988; Thomasson, 2003b, 2007). Preston (2013), who favors a user-based approach, is one of the few opponents of this author-intention-based approach, which she calls “the centralized control model”.

Philosophy of action. Under the influence of Von Wright (1963) and Davidson (1980), in spite of important differences in their analyses (Alvarez & Hyman, 1998), philosophy of action has largely focused on actions whose results are *occurrent* entities, such as moving one's body, running, or speaking. It has largely neglected actions which result in *substances* (e.g., building a house, baking a cake, or electing a president) or actions which result in other kinds of continuants (e.g., learning, which results in a state of knowledge; or promising, which results in obligations). Important exceptions to this tendency, however, are Twardowski (1912), Bühler (1918), Kotarbinski (1965, 29 sqq.), Preston (2013) and Simons (2021), whose work constitutes an important starting point for our research.

Ontology of economics. The ontology of economic phenomena remains a largely unexplored area. Within social ontology, except for money (e.g., Smith & Searle, 2003; Tieffenbach, 2010; Smit et al., 2011; Guala, 2020; Mäki, 2021), economic goods and products have received comparatively little attention. Philosophy of economics, as a branch of the philosophy of science, has mostly focused on methodological, epistemological, and general metaphysical issues as they pertain to economics, such as the nature of explanation and laws, the role of models, or scientific realism (Hausmann, 1984, 2021;

Kincaid & Ross, 2009, 2021; Reiss, 2013 for overviews) as well as on ethical questions (e.g., Sen, 1999; Broome, 1999, 2017), largely leaving aside ontological issues. Finally, within economics itself, while definitional issues used to be heavily discussed among early economists (see subproject 2 below), they have become less prominent in contemporary research. Microeconomics, as presented in today's advanced textbooks (e.g., Kreps, 1990; Mas-Colell et al., 1995), is an application of expected utility theory and game theory, and assumes that preferences primarily bear on actions rather than goods. As a result, our goal of constructing a workable ontology for goods, wealth, capital and their production constitutes an important step forward.

Capacities. Capacities play a central role in the present project, as they can themselves be the products of, and required for, processes of production. While philosophers have long been interested in dispositional properties and powers (e.g., Molnar, 2003; Mumford & Anjum, 2011; Jurati, 2021), the nature of capacities, which we take to be a subclass of dispositional properties, has been less widely studied, at least within ontology. Systematic investigations of human capacities have been conducted in ethics and economics (Becker, 1994; Sen, 1999; Nussbaum, 2011; for an overview, see Robeyns, 2016); as well as in psychology, education, and human resources (Fleishman and Reilly, 1992; Fleishman et al., 1999; Pellegrino & Hilton, 2012). Such approaches, however, tend to focus on *human* capacities and fail to consider the interactions between human and *machine* capacities. Such proposals have also not yet been incorporated into formal and applied ontologies in a way that ensures interoperability. In recent work, Barry Smith, a project-partner, has begun to build the foundations for a formal ontology of capacities, understood as dependent continuants whose performances can be graded as more or less good (e.g., Arp & Smith, 2008; Merrell et al., 2019; Smith & Otte, 2018). Barbara Vetter, another project-partner, is also developing groundbreaking research on abilities (Vetter, 2015, 2019, 2021; Vetter & Jaster, 2017). This research forms a useful foundation on which our own work can build.

Formal and applied ontologies. A *mid-level* ontology whose scope precisely fits the domain of human products and by-products is still missing. Mid-level ontologies, such as the [Common Core Ontology](#) (CCO), contrast with *top-level* (formal or domain-neutral) ontologies, on the one hand, and *applied* (material or domain specific) ontologies, on the other hand. Top-level ontologies, such as [Basic Formal Ontology](#) (BFO) or [Descriptive Ontology for Linguistic and Cognitive Engineering](#) (DOLCE), are general and not tailored specifically to the domain of human products and by-products. Applied ontologies, by contrast, describe only certain kinds of products or aspects of them. For instance, the ontologies developed within the [Industrial Ontologies Foundry](#) (IOF) are aimed at answering the needs of specific industries. Ontologies which do concern the domain of human products and by-products, in our view, tend to overestimate the importance of intentions. For example, an artifact is defined in BFO and the related CCO [Artifact Ontology](#) as “something that is deliberately designed (or, in certain borderline cases, selected) by human beings to address a particular purpose” (Arp, Smith & Spear, 2015, 3; see also Arp & Smith, 2011, §8.1; Kitamura et al., 2003; Mizoguchi et al., 2009; Kassel, 2010).

2.2 Current state of our research. Olivier Massin (OM) has published widely in social ontology, the philosophy of economics, and philosophy of action. His work on dispositions and abilities (Massin, 2009, 2017e; Massin & Bermudez, invited, b) is immediately relevant to our project. OM's publications on the ontology of ownership (2016, 2017a) and the ontology of economic exchanges (Massin & Tieffenbach, 2017; Merrell, Massin & Smith, 2021) directly concern the issues investigated in subproject 2. OM's work in the philosophy of action, on the nature of trying and effort (Massin, 2014; 2017b, e; 2019a; to appear, c; submitted; Massin & de Vignemont, 2020; Massin & Gauchot, 2021; Massin & Bermudez,

invited, a) lays the foundations for our work on the ontology of production. Finally, OM's work on value theory and pro-attitudes (Massin, 2017c, d; 2019a, c, d; 2020; 2021; to appear a, b; Massin & Mulligan, 2021) contributes to our assessment of the axiological aspects of wealth and goods (subproject 2).

Kathrin Koslicki (KK)'s research in neo-Aristotelian metaphysics has helped to reintroduce into metaphysics substantive notions which were part of Aristotle's framework, but until recently have often been ignored by contemporary metaphysicians, such as structure, dependence, essence, definition, and substance. As this more general neo-Aristotelian "movement" continues to garner steam, KK's work has been at the forefront of developing a contemporary defense of one of Aristotle's central innovations, the doctrine ofhylomorphism (Koslicki, 2008, 2018). According to this doctrine, objects are not exhausted by their matter ("*hylē*"), but rather contain an additional component, their form ("*morphe*" or "*eidos*"), which accounts for their structure, identity, and unity. Within the broader neo-Aristotelian framework, KK's work has centered on several more specific sub-areas which are particularly relevant to project: (i) *parts and wholes* (e.g., Koslicki, 2006, 2007, 2008, 2014, 2017); (ii) *grounding, fundamentality, ontological dependence, and substancehood* (e.g., Koslicki, 2012a, 2013, 2015a, 2015b, 2016a, 2016b, 2020b); (iii) *essence, necessity, and real definition* (e.g., Koslicki, 2018a, 2018b, 2020a, 2022a, 2022b, forthcoming c); and (iv) *artifacts* (e.g., Koslicki, 2021, forthcoming a, b). Through her proposed collaborative research with OM, KK will build on and significantly extend her existing work into the realm of human-produced continuants.

KK and OM are connected with several ongoing projects and organizations that are of particular relevance to this project: the [International Society for Social Ontology](#) (ISOS), whose 2020 meeting, organized by OM, brought together over 200 researchers in Neuchâtel; the DFG project, [Human Abilities](#), co-directed by project-partner, Barbara Vetter (FU Berlin); the ERC project, [The Philosophy of Experiential Artifacts](#), led by Enrico Terrone (U. of Genoa), who will be a keynote speaker at an artifacts symposium, co-organized by KK, which will take place in Neuchâtel in July 2022 and is co-sponsored by ISOS; the [The Human Behaviour Change Project](#) (U. College London), which includes our collaborator, Janna Hastings; the [Social Ontology Research Group](#), led by Miguel Garcia-Godinez and Rachael Mellin (U. of Glasgow), to which KK recently contributed a video on artifacts; the [IOE](#), co-founded and co-directed by project-partner, Barry Smith, who also co-created BFO; as well as the [Information and Communication Technology for Sustainable Manufacturing Group](#), led by Dimitris Kyritsis (EPFL). Both Smith and Kyritsis will speak in Neuchâtel in May 2022 at OM's second ontology of economics conference, following the first such event which took place in Neuchâtel in 2019.

OM's and KK's envisaged collaboration promises to break exciting new ground by exploring interconnections between KK's work in metaphysics and the philosophy of artifacts and OM's expertise in the philosophy of law and economics, social ontology, and action theory. OM and KK have already begun to co-author work that is directly relevant to this research project (Koslicki & Massin, forthcoming a, b). In addition, they are co-teaching seminars in social ontology and have created a new course in formal and applied ontologies which will become part of a new interdisciplinary Bachelor program in Data Sciences at UniNE. With their combined track records, OM's and KK's research stands an excellent chance of delivering highly visible and impactful results for the study of human-produced continuants.

2.3 Detailed research plan

General description of the project. The core hypothesis of our project is that there is a general and thus far neglected category of entities, human-made products and by-products, which cuts across many scientific domains. This category includes cities, dams, books, smartphones, screwdrivers, waste, trains, fruits, artificial snow, medicines, nations, pdf documents, laws, and acquired skills. Though heterogeneous in many ways, these phenomena share a key common property: they are all *continuant outcomes of human actions*. Continuants are traditionally contrasted with occurrents (e.g., Johnson, 1921, vol. 1; Simons, 2000; Arp, Smith & Spear, 2015, chap. 6). Tennis games, sunsets, meiosis, and explosions, for example, are occurrents; tennis balls, the sun, cells, or bombs, in contrast, are continuants. Both continuants and occurrents exist in time, as opposed to abstract entities such as sets or numbers. Continuants are three-dimensional entities which persist through time by being “wholly present” at each time at which they exist, while (non-instantaneous) occurrents are four-dimensional entities which persist through time by virtue of having temporal parts. Continuants have lives or histories associated with them; but these latter entities are occurrents. The life of a tree, for example, has various temporal parts; but the tree itself (arguably) lacks temporal parts. While the distinction between continuants and occurrents is subject to controversy at the level of foundational metaphysics (cf., e.g., Parsons, 2000; Sider, 2005), it is of central relevance to descriptive metaphysics (see below) and has proven to be highly fruitful for the development of ontologies for the special sciences. In particular, the continuant/occurrent distinction occupies a central position within the two leading upper-level ontologies, BFO and DOLCE.

Not all continuants are the outcomes of human actions: mountains, atoms, wild animals, for example, need not be human-produced continuants. In addition, not all human actions have continuants as outcomes: an outcome of the action of screaming is a scream, i.e., an acoustic occurrent; an outcome of the action of moving one’s arm is the motion of one’s arm, i.e., a kinematic occurrent; an outcome of the action of baking bread is the heating of the dough, i.e., a chemical occurrent. Our project focuses on those outcomes of human actions that are continuants, and on those actions which have continuants as outcomes: we use the terms, “*product*” and “*by-product*”, to refer to the former; and the terms, “*production*” or “*productive actions*” to refer to the latter. So understood, human-made products and by-products include *material continuants* such as spoons and cable cars; *immaterial continuants* such as computer programs and contractual obligations; *dependent continuants* such as capacities acquired through education, and *institutional continuants* such as universities or laws. The orientation of our project is novel in at least the following three respects.

(i) *Scope.* The scope of our research, human-produced continuants, is new and more encompassing than that of existing bodies of work in related areas (§2.1). Philosophy of action has focused primarily on actions whose results are occurrents, neglecting the category of continuant-producing actions. Social ontology tends to focus on institutional phenomena (e.g., marriage, money, property) and less so on capacities and artifacts. The philosophical literature on artifacts takes as its paradigm cases material products and by-products, rather than institutional or economic phenomena, immaterial phenomena (e.g., in the digital domain), or learned human capacities and skills. Economics, sociology, anthropology, education, and archeology focus on specific kinds of products and by-products. Among the chief interests of our proposed work is to bring out that a wide variety of research areas, which seem at first to be disconnected and independent, in fact share a common subject-matter: all are engaged in the study of human-made products and by-products. So as to keep the scope of our project manageable, our current investigation will not include products made by *non-human* animals (e.g., spiderwebs, beaver dams, or birds’ nests), though these phenomena raise extremely interesting

questions in their own right which deserve to be taken up separately in future research. For the time being, we thus restrict ourselves to the continuant outcomes of *human* activities.

(ii) *A non-intentionalist approach.* It is our contention that too much emphasis has been placed in the philosophy of artifacts, action theory, and social ontology on intentional acts and their intended products, thereby sidelining non-intentional actions, as well as unintended outcomes of intentional acts. According to our hypothesis, while human products and by-products must be made by human agents, processes of production as well as the outcomes produced by them need not be intentional: rather, these acts and their outcomes may be either intentional or non-intentional. This hypothesis goes against standard ways of drawing the product/by-product distinction, according to which the by-products of an action, in contrast to its products, consist in the action's unintended or unforeseen consequences. Such a proposal, however, is subject to various counterexamples. First, some by-products are intended: sawdust, for example, can be used as mulch, cat litter, fuel, an ingredient for papermaking, etc., and is often an intended by-product of woodworking. Secondly, some products are unintended. For example, a misspelled word can be the product, rather than the by-product, of an agent's unintended misspelling of the word in question. In the domain of artifacts, products (e.g., bubble wrap), which are initially intended to be used in one way (e.g., as wall paper), sometimes turn out to be put to a very different use (viz., for packaging). Finally, the literature on action recognizes, in addition to intentional and unintentional actions, a further category of *non-intentional* actions, such as habits (Gorr & Horgan, 1982; Chan, 1995; Bratman, 1987, chap. 8; Johns, 2020). If correct, an agent's automatic behavior (e.g., mechanically operating a coffee machine in the morning without paying attention) may sometimes lead to non-intentionally produced continuants (viz., coffee). We propose to explore a more neutral way of drawing the product/by-product distinction, which relies on Von Wright's (1963) distinction between the *results* and the *consequences* of actions. While an action (e.g., opening the door) is arguably essentially tied to its result (viz., the opening of the door), it is only accidentally tied to its consequences (e.g., the cooling of the room). By extending this distinction to actions whose outcomes are continuants, we aim to investigate the hypothesis that the product of an action corresponds to its continuant result, while the by-product of an action corresponds to its continuant consequences.

(iii) *A capacity-centered approach.* We conjecture that capacities play at least the following two central roles in an ontology of production, products, and by-products. First, given that capacities have been assigned to the category of dependent continuants (e.g., Arp, Smith & Spear, 2015), *produced* capacities (e.g., capacities acquired through teaching) should be included in an ontology of products and by-products. One question to be addressed is whether capacities are products or intended by-products of learning activities. Does a driving lesson *result* in a new skill, or is such a skill only one of its *consequences*? Secondly, capacities are not only produced, they are also themselves needed to bring about products and by-products. A central question to be explored in this connection concerns the interaction between *human* capacities and the capacities of *machines*, which is complex and requires proper regimentation: on the one hand, machine capacities *confer* on us new capacities; on the other hand, machines and other human-made products have capacities only insofar as we in turn have the capacities to use them. As we explain below, the distinction between actual and potential capacities, which will be of help in answering these questions, occupies a central role in both subprojects.

Our project thus aims at developing a general ontology of human-made products, by-products and their production, conceived of in a sufficiently wide-ranging manner so as to include material and immaterial (e.g., digital) artifacts, institutional and legal entities, as well as acquired capacities. We shall refer to this ontology as "PROBO" (short for

“*Product/By-Product Ontology*”). An ontology is itself a product designed and constructed by humans for a certain purpose, namely, to ensure greater levels of clarity in the use of technical vocabulary as well as increased shareability and accessibility of data within a single discipline or across different disciplines. More precisely, an ontology can be construed as a representational artifact comprising (i) a taxonomy of the relevant kinds of entities, which can be represented by means of hierarchical tree-like graph-structures using the “is-a-subclass” relation; (ii) definitions for all terms; as well as (iii) a representation of the key relations between entities in the domain in question (Arp, Smith, and Spear, 2015). Once we have arrived at a clear ontological representation of human-made products and by-products in ordinary language, we shall represent and implement PROBO using the tools of first-order logic, OWL (Web Ontology Language) and [Protégé](#) (a free and open-source platform for constructing ontologies), following current guidelines and best practices for building ontologies, in order to ensure that our ontology can be widely used by other researchers.

As noted earlier, top-level ontologies utilize only the most general terms that are applicable across all domains (e.g., “continuant”, “occurrent”) and hence their construction requires a philosophical skill-set. Applied ontologies, on the other hand, concern particular scientific domains and are couched within a specialized technical vocabulary (e.g., “cell”, “gene”). PROBO, by contrast, is a *mid-level* ontology: it pertains to a wide range of disciplines (e.g., economics, social ontology, law, theories of artifacts, archeology, industrial design), but does not encompass all domains (e.g., the natural sciences). To develop such an ontology, we employ three methodological assumptions.

Descriptive ontology. A descriptive approach, we believe, should take priority in the order of investigation over attempts to formulate foundational analyses of the phenomena under investigation (Koslicki & Massin, forthcoming a). The goal of a descriptive approach is to take seriously how entities within a particular scientific domain appear to us, by contrast to attempting to reduce or explain them away (e.g., Arp, Smith & Spear, 2015, 46; Fine, 2017). While we by no means deny the importance of arriving at good explanations, we want to insist that any such foundational project must be premised on first having a clear picture of what the phenomena of a given domain are. Attempting to propose explanations prematurely, without first having taken the time to map out the entities of a domain in their rich detail, can lead to a skewed perspective which overlooks central distinctions, such as the aforementioned distinction between intended and non-intended by-products, or the distinction between actual and potential capacities to be investigated below.

Shared definitions. We shall assume that such questions as “What is wealth?”, “What is a machine?”, etc., have correct and incorrect answers; that they are subject to rigorous scientific inquiry; and that answering such questions is essential to good scientific practice (Koslicki & Massin, forthcoming b). Shared definitions are necessary, first, because to carry on a meaningful debate in an area, one has to agree that there is a common subject-matter. For instance, if we are to disagree about the evolution of wealth-concentration, we need first to agree on what wealth is. Second, a lack of shared definitions leads to data silos. For instance, labeling something as “wealth” that is labeled as “capital” by another research group can lead to data-fragmentation.

Top-down and bottom-up approaches. Mid-level ontologies such as PROBO require a combination of top-down and bottom-up approaches. The top-down aspects of our project utilize standard philosophical tools such as conceptual analysis and relying on BFO and DOLCE, whose respective co-founders, Barry Smith and Nicola Guarino, are both project-partners. The bottom-up aspects of our approach are geared towards gathering definitional claims and distinctions that are used across many disciplines and research areas and receiving feedback from experts in these fields. Indeed, while

a top-down approach on its own runs the risk of obliterating important distinctions and connections among specific human-produced continuants, a bottom-up approach by itself threatens to miss out on important features that are shared between the phenomena under investigation. The bottom-up aspects of our project are carried out by focusing on two distinct but overlapping classes of human products and by-products: artifacts (subproject 1) and economic goods (subproject 2). We expect that the general framework just outlined will allow us shed light on these domains; conversely, the results of our subprojects on economic goods and artifacts will in turn help us refine our overall approach to the ontology of products and by-products.

Our project proceeds by means of four work-packages (W1-W4) whose contents are explained in more detail below. Our research-team consists of the two PIs, KK and OM; two doctoral students (doc1 & doc2), supervised by KK and OM, respectively; as well as a postdoctoral fellow (postdoc), co-supervised by KK and OM. The doctoral students and postdoc will be recruited on the basis of an international competition.

Work-package 1 (W1) focuses on the construction of ontologies and will be among the postdoc's key responsibilities under KK's and OM's supervision. W1 proceeds by way of the following stages:

Year 1: Preparatory work for ontology building.

Year 2: Construction of artifact-ontology, PROBO-ART (subproject 1); and ontology of economic goods, PROBO-ECON (subproject 2).

Year 3: Integration of PROBO-ART and PROBO-ECON into general product ontology, PROBO.

During this process, we will aim for compatibility with the two most widely used upper-level ontologies, BFO and DOLCE. Computer-scientist, Janna Hastings (St. Gallen/Zürich) will be invited to teach workshops designed to familiarize all team-members with the basic principles and best practices of ontology-construction.

Subproject 1: Artifacts

1. Artifactual function, malfunction, and prototype-production. Our first subproject on artifacts, led by KK with assistance from doc1, takes as its starting-point the central question of how best to understand the notion of artifactual function and its correlative notion of malfunction. An artifact's function is what the artifact is *supposed* to do; a *malfunctioning* artifact (e.g., a knife that cannot cut) is one that cannot do what it is supposed to do. Given the emphasis on intention in the existing literature on action and artifacts, it is commonly held that the functions of artifacts are determined by the intentions of agents who design or produce them. Thus, according to author-intention-based approaches, the fact that screwdrivers have the function they do, viz., to tighten and loosen screws, derives from the fact that they were designed and built by agents who had the intention of fashioning devices that could be used by competent users in the right circumstances to tighten and loosen screws. While screwdrivers can no doubt be *used* in many other ways, e.g., as weapons, author-intention-based approaches hold that it is the intentions of agents responsible for the design and creation of this type of artifact that single out the *intended proper* function of screwdrivers, viz., tightening and loosening screws, from among the nearly endless variety of other accidental uses to which these devices can be put.

In this connection, our practice of ascribing functions to artifacts differs markedly from the corresponding practice of ascribing functions to the traits or parts of organisms in the biological realm, where (excluding theistic frameworks) agential intention does not play a comparable role in motivating and justifying the ascription of a function to a trait or part of an organism (e.g., Ariew, Cummins & Perlmann, 2002). Supposing for example that the primary function of a (non-

artificial) heart is to pump blood, the fact that (non-artificial) hearts are able to carry out this function within organisms does not similarly derive from the fact that human agents designed and built (non-artificial) hearts with the intention of creating a device that could carry out this function within the organism. Rather, in the biological case, it is presumably the fact that a trait or part of an organism is selected for, and thus has a certain evolutionary history, that explains why the function of a heart is to pump blood, rather than, say, to produce a regular pattern of thumping sounds.

The appeal to agential intentions in our practices of ascribing functions to artifacts thus undoubtedly has certain advantages. Nevertheless, author-intention-based accounts also give rise to a number of difficulties discussed in Koslicki (2018, ch. 8). To illustrate, consider a case of prototype-production. Suppose, for example, that Alexander Graham Bell, the inventor of the telephone, initially intended his new device to be used to amplify sound in order to aid the hearing-impaired, while later users came to think of the telephone as a certain type of long-distance communication device which allows two or more users (whether they are hearing-impaired or not) to carry on a conversation even when they are far apart. Regardless of what Alexander Graham Bell may have originally intended, we now take the telephone to be a device which enables long-distance communication, and not a hearing-aid. This scenario suggests that it is in fact possible, under certain circumstances, for the intentions and practices of later users to override the intentions of the original author as to how the device she has invented, designed or produced is to be used (Kornblith, 2007). As it stands, however, such a possibility appears to be incompatible with author-intention-based accounts, since these approaches maintain that the sole authority for determining an artifact's kind-relevant features resides with the intentions of those agents who are responsible for the design and production of the artifact in question (though see Eynine, 2022, for a recent response).

A very different account of prototype-production, and the nature of artifacts in general, is presented in Preston (2013). In Preston's view, an artifact's kind-membership is not tied to the intentions of the artifact's original author, since she rejects the author-intention-based orientation that is prevalent in the philosophical literature on artifacts and action more broadly. According to Preston's user-based account, an artifact's kind-membership is also based on the artifact's function. In determining what an artifact's function is, however, Preston does not privilege author-intentions; rather, she is a pluralist and allows that an artifact's function may be either its "system function" (Cummins, 1975), i.e., a current capacity which the whole artifact (the system) inherits from the current capacities of its parts (the system's components); or its proper intended function (Millikan, 1984), i.e., a trait which contributes to the survival, proliferation, or reproduction of the system or component in question (see also Elder, 2007).

While Preston's user-based account of artifacts works well in a range of cases, it in turn encounters challenges of its own also involving prototype-production. To illustrate, suppose that an agent has devised a brand-new strategy by which to open tin cans and sets out to build a prototype of the first-ever "can-opener". According to the agent's novel strategy, the device in question is to cut open a can's lid by running a sharp rotating wheel along the can's rim. This scenario admits of at least the following two outcomes. In Case 1, the device in question successfully implements the agent's novel strategy for opening cans. In this case, the device can be correctly classified as a can-opener on the basis of its system function: for, based on the current capacities the device has in virtue of its components and how these components are put together, it is able to be used as a can-opener in the manner envisioned by the agent in question. In Case 2, however, the device fails to implement the agent's novel strategy for opening cans successfully, perhaps because the device lacks an appropriate mechanism to grip the can's rim tightly enough to allow its sharp rotating wheel to cut the can's lid by running alongside the can's rim. In this case, a user-based framework appears to lack any grounds on the basis of which the device could be

classified as a can-opener (or, for that matter, as another kind of artifact). After all, the device, by hypothesis, lacks the current capacity to open cans in accordance with the agent's novel strategy; and, given that we are dealing with a case of prototype-production, there is also no history of use and reproduction which could justify the ascription of a proper intended function to the device in question on causal-historical grounds. In this case, Preston's user-based account places us in the uncomfortable position of apparently having to recognize concrete particular objects whose nature and kind-membership are in certain respects not fully determined.

We take considerations such as those just cited to indicate that neither author-intention-based approaches nor user-based approaches yield a fully satisfactory account of artifact-functions, malfunctions, and prototype-production. In their place, we aim to develop an alternative approach that is less agent-centered and instead puts greater emphasis on the object itself and its capacities. Given the phenomenon of malfunction, however, the relevant conception of capacities must be sufficiently broad to include not only an object's actual or current capacities, but also its potential capacities, i.e., those capacities an object can acquire, for example, if it is repaired or otherwise modified. In addition, an object-centered approach must also provide a systematic answer to the question of how to differentiate an artifact's function from the many accidental uses to which it can be put (Wakefield, 2005). Koslicki has already begun to work out some of the details of this object-centered approach in several of her forthcoming single-authored papers (Koslicki, forthcoming a, b, c). Other as-of-yet open questions will be taken up and addressed during the course of subproject 1.

2. Actual and potential capacities. An important second component of subproject 1 focuses on the distinction between *actual* and *potential capacities*. Since our hypothesis is that the functions of artifacts should be conceived of as (actual or potential) capacities of objects, we must now situate artifactual functions within the more general ontological category to which they belong, viz., a category which includes not only functions, but also other types of capacities, dispositions and skills. We propose to elucidate this broader category in part by appealing to an attractive account of "*potentialities*" that has recently been proposed by project-partner, Barbara Vetter (Vetter, 2015). According to Vetter, objects have certain properties (e.g., abilities or dispositions) which concern what a given object or objects *can* do; any such property is a potentiality. Potentialities, for Vetter, are thus possibilities rooted in objects.

How are an object's actual capacities distinct from its potential capacities? Our working hypothesis is that an object's potential capacities can be conceived of on the model of what Vetter calls "*iterated potentialities*": an iterated potentiality is, roughly, a potentiality for further potentialities (ibid., 135-139). An actual or current capacity, in contrast, is a non-iterated potentiality, i.e., something an object can already do in its present state, without first having to acquire another potentiality. For example, a person who has not yet learned how to play the violin lacks the non-iterated potentiality to play the violin, but nevertheless has the iterated potentiality to play the violin: she has the potentiality to acquire the potentiality to play the violin by learning how to play the violin. We conjecture that Vetter's distinction between iterated and non-iterated potentialities will prove helpful to us in developing a non-agent-centered account of artifactual functions which can account for the phenomenon of malfunction. By means of this distinction, a malfunctioning can-opener prototype, for example, can be characterized as a device which has an iterated potentiality (i.e., a potential capacity) to open cans in the manner described: it has the potentiality to acquire the potentiality to open cans in the manner envisioned by the agent, e.g., by being repaired or otherwise modified in an appropriate manner. The device's iterated potentiality can then serve as a basis for classifying the malfunctioning prototype as a can-opener, despite the fact that it cannot in its current state be used to implement the agent's novel strategy for opening cans. The actual/potential-capacity distinction will play a central

role in our development of PROBO and as well as in subproject 2, in particular in connection with our proposed characterization of wealth described in more detail below.

3. Digital entities. In Year 2 of subproject 1, we turn to a relatively neglected sub-kind of artifacts, viz., digital entities. Although digital entities have been studied, for example in Smith (2015), no ontology for digital entities has as of yet been constructed. We propose to fill this gap by incorporating digital entities as a subclass of artifacts into the larger ontology of production, products, and by-products which will constitute one of the tangible outcomes of our project. By “digital entities”, we mean entities brought about through digitalization, e.g., computers, smartphones, autonomous vehicles, and in general entities that are included in the so-called “Internet of Things” (IoT); but also software, websites, avatars, social media profiles, NFTs, mobile phone applications, chatbots, electronic data and money, virtual universities, and the like. Among digital entities, an initially plausible division into those that are *material* and those that are *immaterial* suggests itself, thus raising the question of how these two subkinds, material and immaterial digital entities, are related to one another.

In addition to the distinction between material and immaterial digital entities, further taxonomic divisions, such as those between (material or immaterial) digital entities that are *continuants* and those that are *occurrents*, can be imported from the general BFO framework into the digital domain. To illustrate, a virtual fight, e.g., between two avatars in a video game, just like its non-virtual counterpart (e.g., a non-virtual fight between two flesh-and-blood people) is a process, i.e., a type of *occurrent* entity which persists through time by having (e.g., earlier or later) temporal parts. In contrast, electronic currency, such as bitcoin, just like its non-electronic counterparts (i.e., coins and bills), appears to be a type of *continuant* entity which persists through time, not by having (e.g., earlier or later) temporal parts, but rather by being wholly present at each time at which it exists. This apparent relationship between (material and immaterial) digital entities and their non-digital counterparts suggests, as a working hypothesis, that digital entities will follow their non-digital counterparts, where applicable, when it comes to their membership in general ontological categories (e.g., continuant vs. occurrent): thus, if a non-virtual document, for example, is a continuant, then so is a virtual document; and similarly for digital and non-digital occurrent entities.

A third distinction among digital entities we will examine is that between “*virtual*” and “*non-virtual*” entities. The virtual/non-virtual distinction raises a whole host of interesting questions which have already attracted some attention from philosophers (e.g., Brey, 2003; Chalmers, 2007), but which call for more systematic investigation in their own right. Although the *virtual* might initially appear to be *unreal*, it is not obvious that the virtual/non-virtual distinction in fact lines up in this way with the distinction between what is unreal and what is real. In some cases (e.g., the digital twin of a car or a patient’s brain), the inference from “virtual” to “unreal” certainly does seem to be felicitous. For example, a digital twin of a car is a virtual entity which allows one to keep track of the location, speed, fuel consumption, maintenance schedule, etc., of its non-virtual counterpart; nevertheless, there is no temptation to think that the digital twin of a car can be used as a mode of transportation, alongside non-virtual cars. Similarly, a brain surgeon might find it easier to operate on the digital twin of a patient’s brain; but we are not likely to confuse the digital twin of a patient’s brain with a real brain. In other cases, however, virtual entities do seem to have at least a claim to being considered real, alongside their non-virtual counterparts. For example, a student who is enrolled at a virtual university will at the end of their studies be awarded a degree which, at least in theory, is supposed to have the same status as a degree obtained from a non-virtual university. Similarly, virtual shops offer a variety of products to their customers and generate income for their owners, just like their non-virtual brick-and-mortar counterparts. Some shops have both virtual and non-virtual manifestations, which raises

interesting questions as to how these virtual and non-virtual aspects are related. Given these apparent counterexamples to the generalization that what is virtual is unreal, we intend to formulate a more nuanced position which, at least in principle, allows for the possibility that virtual entities can, under certain circumstances, nevertheless be real.

4. Human vs. machine capacities. In Year 3 of our subproject on artifacts, we explore the relation between *human capacities* and *machine capacities*. While recent work in ontology has paid particular attention to the nature of dispositional properties and powers as well as to the nature of functions, e.g., in the biological or artifactual realm, the relation between these and human and machine capacities remains largely unexplored (but see Arp & Smith, 2008, for a promising starting-point). With the rapid advance of AI, robotics, the internet of things, the metaverse, and Industry 4.0, there is an urgent need to develop tools to assess the impact of machines on the human abilities. For instance, singling out the peculiarly human skills and meta-skills that will still be needed in the labor market as digitalization takes over is among the main challenges that lie ahead.

Though important taxonomies of human skills and abilities have been developed, especially for human resources and educational purposes (§2.1), the varieties of machines capacities and the way they complement or compete with human capacities remain under-explored. To remedy this, we shall pay particular attention to machine capacities that are becoming increasingly relevant as part of the ongoing fourth industrial revolution (data driven manufacturing, zero-defect manufacturing, predictive maintenance, industrial IoT, etc.). Existing work on the ontology of manufacturing, some of which is carried out by project-partner, Barry Smith, and his collaborators (see, e.g., Ali, Rai, Otte & Smith, 2019; and Kiritsis' and Smith's pioneering work for the [Industrial Ontologies Foundry](#)), will constitute a useful starting point for the development of our product ontology which takes into consideration the digital domain as well as human and machine capacities.

Once we have gained a clearer picture of the varieties of human and machine capacities, we will be in a better position to map out their interactions. How, for example, should we distinguish cases in which the use of digital entities expands human capacities from cases in which we defer to digital entities so as to rely on machine capacities instead of exercising our own? Are GPSs and other wearables external devices that supplant our capacities, or are they part of our “extended minds” (Clark & Chalmers, 1998) that expand our capacities? Such questions have important normative implications. For instance, while the responsibility for actions that are performed by humans with the help of standard tools lies with human agents, the question of how to allocate the responsibility for actions performed by, e.g., semi-autonomous vehicles, presents a much more difficult challenge. To sort out the varieties of interactions between human and machine capacities, we start by considering positive cases in which machines (i) *endow* us with new human capacities; (ii) *enhance* existing human capacities; (iii) *correct* existing human deficiencies; (iv) *facilitate* the exercise of human capacities. These must be distinguished from negative cases in which machines, as a side-effect, render human skills useless or contribute to the vanishing of human capacities. The distinctions we propose to draw between the *results* and the *consequences* of processes of production, as well as those between *actual* and *potential capacities*, will be extremely relevant to our taxonomy of the kinds of interactions between machines and human capacities.

Throughout subproject 1, we will implement our bottom-up approach with respect to subproject 1 by working in close consultation with archeologist and project-partner, Géraldine Delley, our colleague at the University of Neuchâtel. Delley is deputy director of the *Laténium* (Neuchâtel archeological museum) and has published widely on such questions as the classification of artifacts, which are of central importance for subproject 1. Delley co-directs a seminar on objects and

recently organized an exhibition entitled, “[Des choses](#)”, accompanied by an edited volume (Delley, 2021), on taxonomically problematic artifacts. Our collaboration with Delley will also be directly relevant to the assessment and development of PROBO-ART.

Work package 2 (W2) will be carried out during Years 1-3 of the project and will be led by KK, with the assistance of doc1, though aspects of W2 will also involve other team-members. W2 focuses on the main research questions of subproject 1 as outlined above:

Year 1: (1) Artifacts, artifactual functions, malfunction, accidental uses, prototype-production; (2) actual and potential capacities. (Project-partner visit: Barbara Vetter)

Year 2: (3) Digital entities.

Year 3: (4) Human vs. machine capacities. (Project-partner visit: Michael Raven)

Dissemination of W2’s research results concerning (1)-(4):

KK’s single-authored publications, planned and underway (Koslicki, forthcoming a, b, c).

Doc1’s doctoral dissertation.

Paper on artifact-functions, malfunctions, & prototype-production (KK).

Paper on conceptual foundations for an ontology of artifacts (KK & postdoc).

Paper on human and machine capacities (KK & OM).

Paper on the ontology of digital entities (KK, OM, & postdoc).

Annual conferences organized by team-members.

Special issues of the journal, *Metaphysics*, on functions, digital artifacts, and capacities, co-edited by KK & Raven.

Integration of W2’s research result into W1 (PROBO-ART) and W4 (capstone projects, described below).

Subproject 2: Wealth, Goods, and Capacities

Our second subproject, led by OM with the help of doc2, aims at developing an ontology of goods, wealth and capital, as well as their relation to capacities. The production of wealth has been at the heart of economic thinking since its infancy. Plato, in the *Republic*, builds his ideal city upon the producer class (*Rep.* II, 370a-b). Aristotle at length discusses productive sciences and wealth (*Politics*, 1256 b30-34; *Ethics*, 1096 a5-6; *Politics*, 1258 b2-8). Adam Smith defines economics as the “science of wealth”, a definition taken up by Malthus (1820), Say (1851, chap. 1, sec. 1), Walker (1867), Cannan (1914), to mention but a few. Both Malthus and Say, however, complain that the definition of wealth was one of the most difficult yet central tasks of political economy. Two centuries later, an agreed upon definition of wealth, clarifying its relations to goods, capacities and capital is still sought. To illustrate, Piketty (2013, 46) equates capital and wealth which he defines as the “sum total of nonhuman assets that can be owned and exchanged on some market”. McCloskey, one of our project-partners, objects that such a definition unduly excludes human capital (McCloskey, 2014). The question is of importance because including human capital, so McCloskey argues, would undermine Piketty’s thesis of an ever-growing concentration of wealth. Such a lack of agreed-upon explicit definitions undermines the possibility of meaningful disagreement, hampers interdisciplinary collaborations, and hinders data integration within economics and across other fields. In line with the standard rationale for ontologies, we hypothesize that an ontological approach to wealth constitutes part of the solution to this problem. A similar approach has been successfully applied to economic exchanges. Based on a

review of various explicit and tacit definitions in the literature, Massin & Tieffenbach (2017) propose a definition of economic exchanges reconciling their essential elements. Vajda, et al. (2019), Porello et al. (2020a, 2020b), Blums & Weigand (2020), and Merrell et al. (2021) have subsequently developed various ontological implementations of this definition of exchanges in BFO and DOLCE. The same approach will be applied here: based on an extensive review of the existing literature, we shall extract the chief definitions of wealth, goods and capital and try to reconcile them in a common ontology. For this, we shall focus on the following three central questions: (1) What are the relations between services and wealth? (2) What are the chief definitions of wealth and capital used in the literature and how can they be reconciled? (3) What are the relations between the wealth of a person, her capacities and the capacities of what she owns?

1. Wealth, goods, and services. Are services pieces of wealth? Smith (1776, Bk II, chap. 3) answers negatively. But others maintain that services are indeed articles of wealth (e.g., Say, 1851, 120; Robbins, 1932, 9; Galouj, 2002; Klick & Parisi, 2005). Indeed, the view that services are pieces of wealth is presupposed when wealth is equated to utility or value (e.g., von Wieser, 1892; Posner, 1985) or when GDP is taken as a measure of the wealth of a country; for GDP incorporates services. (See McCloskey's (2016, 79) definition of "Great Enrichment" in terms of production of goods and services.)

We will rely on five ontological distinctions to settle this dispute while preserving the key insights of both sides. We shall first assess the hypothesis that goods are *continuants*, while services are *occurrents*. If correct, Smith was right not to count services as pieces of wealth, in spite of their being useful, exchangeable, and contributing to economic growth. Indeed, one of the few uncontroversial assumptions about wealth in the economics literature is that wealth, contrary to income, is a stock and not a flow (e.g., Fisher, 1897; Sowell, 2011, 150-1; Milanovic, 2015; Blanchard, 2020, 89). Wealth, in other words, can be accumulated; but services, qua *occurrents*, cannot be accumulated. One can stockpile houses, money, flour, paintings; but one cannot stockpile flights, musical performances, lawn mowing or dental cares. Services, contrary to goods, are destroyed, i.e., consumed, right when they are produced. We thus expect the *continuant/occurrent* distinction to help place Smith's original insight on firmer ground.

The second step will be to accommodate key insights motivating the view that services are pieces of wealth. The following four other ontological distinctions will be explored in this connection. (i) *Services vs. intangible goods* (Hill, 1976, 1999; Ferrario & Guarino, 2008; Massin & Tieffenbach, 2017; Guarino, 2018; Otte et al., 2019). We shall hypothesize that intangible goods, which include computer programs, physical/intellectual/legal capabilities, rights and claims, etc., are immaterial *continuants*. Contrary to services, with which they are sometimes conflated, intangible goods can be accumulated, and are pieces of wealth. (ii) *Services vs. rights to services*. If Bob is offered a voucher for a hotel night, the voucher, a right, is a piece of wealth; but the hotel night, to which he is entitled, is not a right but a service. One can accumulate vouchers; but one cannot accumulate hotel nights. Contrary to services, rights to services are pieces of wealth. (iii) *Results of services vs. consequences of services*. Relying on the distinction between the result and the consequence of an action introduced above, we conjecture that, while services and their results are *occurrents*, some of their consequences are *continuants*. A driving lesson is a service, hence an *occurrent*. When things go well, such a lesson has, among its *consequences*, the capacity to drive and a driving license, both of which are *continuants*. Contrary to services, consequences of services may be pieces of wealth. (iv) *Transfer of goods vs. provision of services*. Say (1851) argued that, since services can be exchanged, they must "pass from the producer to the consumer", and that whatever is transferable is a piece of wealth. In response, we plan to elaborate on a distinction introduced by Massin and Tieffenbach (2017) between *transferring* a good

and *providing* a service, to the effect that services are exchanged without being transferred. If correct, one cannot conclude from the exchangeability of services that they are pieces of wealth. In sum, we expect that, by relying on overlooked categorical distinctions in the ontology of economics (continuants *vs.* occurrents, services *vs.* immaterial goods, services *vs.* right to services, results *vs.* consequences of services, transfers *vs.* provisions), we will be able to defend the view that only goods are pieces of wealth, while at the same time preserving the insights motivating the view that services are pieces of wealth.

2. Definitions of wealth. Narrowing down pieces of wealth to continuants is already an important result; but it does not yet yield a definition of wealth. The goal of the second part of subproject 2 is to arrive at a definition that reflects the actual practice of researchers using the concept of wealth. To this end, a central task will be to retrieve, contrast and classify the various explicit and tacit definitions of wealth that are used not only in economics, but also in philosophy, anthropology, or sociology. Such a mapping of the different conceptions of wealth, which has not yet been achieved (see, however, Reda, 2018), will constitute a first important advance. From there, we shall aim at formulating a unified and comprehensive definition of wealth. Anthropologists have revealed the wide variety of forms that wealth can take across cultures and history, stressing that not all wealth is monetary or dependent on a market (Malinowski, 1922; Polanyi, 1944; Guyer, 1997; Rakopoulos & Rio, 2018, 2020). An operational definition of wealth should not exclude any of these forms of wealth; quite the contrary, it should capture the core concept of wealth that allows one to identify wealth across cultures. Likewise, philosophers and economists have debated whether wealth, particularly social wealth, is valuable (Dworkin, 1980; Posner, 1980, 1985; Johnsen, 1986). A good definition of wealth should not beg the question in favor of any particular answer to these questions.

As it presently appears to us, two broad conceptions of wealth can be identified in the literature: we call the first “*ownership view*”, and the second “*capacity view*”. The *ownership view*, on the one hand, defines the wealth of a person (or of a family, a nation, an institution, etc.) as the collection of valuable things that this person owns (Ricardo, 1817; Malthus, 1820, 33; Mill, 1848, ch. III; Senior, 1849, 6 sqq. ; Cannan, 1888; Marshall, 1890, Bk II, ch. II; Marx, 1867; Fischer, 1906, 4; Menger, 1871, ch. II, §4; Walras, 5th lesson, §21; Rutherford, 2013; Piketty, 2013, 46). Various versions of the ownership view may be distinguished, depending, for instance, on how the value of things is defined (e.g., in term use- or exchange-value; see Bastiat, 1851, chap. VI for a defense of the first view; and Broome, 1991, for various senses of “utility” in economics). A standard refinement of the ownership view equates the *net* wealth of a person with the value of what she owns minus the value of what she owes: assets minus liabilities. Further distinctions are often introduced within this general approach to wealth, for instance between financial wealth, housing wealth and human wealth (Blanchard, 2020, 332).

The *capacity view*, on the other hand, defines wealth as a capacity, such as the capacity to fulfil one’s desires or the capacity to exchange. Drawing on Hobbes, who equates wealth with power, Smith construes wealth as the capacity to afford the “the necessities, conveniences, and amusements of human life” (*Wealth of Nations*, Bk 2, ch. V; see also Helleiner, 1951), and further defines wealth in terms of the power of purchasing, which, under his labor theory of value, corresponds to the amount of labor that one can command. Keynes (2010 [1940]) equates wealth with the capacity to postpone consumption. More recently, the capacity view has been defended by Sen (1993, 2001) who defines “well-being freedom” in terms of *capabilities* to achieve good things and Milanovic (2020). The capacity view is more widespread when it comes to the definition of capital. Becker’s (1964) influential work on *human capital* argues that skills, knowledge, health

and education should be counted as capital, although they are not clearly transferable. Ostrom (1994, 2000, 2009) argues that *social capital* is a key component of capital. McCloskey (2016) suggests that virtues such as temperance, prudence or justice constitute a *moral capital*. Capacity views have also been influential outside of economics. In evolutionary anthropology, Mulder and Beheim (2011) stress that wealth includes not just goods, but also status, skills, or kin network. In philosophy, Brennan & Pettit (2004) argue that *esteem* is a capital good. In sociology, Bourdieu (1986) introduces the concepts of *cultural and social capitals* to complement the overly narrow concept of economic capital.

These two views of wealth (or capital) correspond to two common uses of the term “wealth” in ordinary language (Cannan, 1914, 3), which can sometimes mean valuable objects owned by persons, and other times capacities or conditions of persons, on a par with “health”. “*Vermögen*”, in German, displays this ambiguity even more clearly. Each view entails under plausible assumptions that services are not pieces of wealth, in line with our previously mentioned hypothesis. Ownership views exclude services because, arguably, they cannot be owned (Reinach, 1983; Massin, 2015, 2017). Capacity views exclude services, since capacities are dependent continuants (Arp & Smith, 2008; Merrell et al., 2019), while services are occurrents. Can these two definitions be reconciled so as to arrive at a shared definition of wealth? There are at least three options, which we shall explore in turn.

(i) The first option is to reduce the capacity view to the ownership view by including capacities among the items we own. Wealth, on this version of the ownership view, would be the ownership of valuable items, *which include capacities*. We will consider various problems for this reductionist proposal. First, it is controversial whether we really *own* our capacities, by contrast to simply *having* them, in the same way as we have beliefs or character traits. It is not clear, for instance, that a person has property rights over capacities. Second, pieces of wealth, it is often claimed, must be transferable (Senior, 1848, 8; Marshall, 1920, 45-7; Piketty, 2013, 46); but whether capacities are genuinely transferable is a question that must be examined in detail. Third, including capacities among pieces of wealth generates double counting issues. Owning a chainsaw gives one the capacity to cut wood; but it would be redundant to count this capacity as an additional piece of wealth on top of the chainsaw itself, as the present proposal would entail (Fisher, 1906, 4). Fourth, one reason why we want more wealth is that wealth brings esteem or power (Smith, 1887; Veblen, 1912; Brennan & Pettit, 2004, 7). But if esteem or power are pieces of wealth, as per the present proposal, then we want wealth because it brings wealth.

(ii) In view of such difficulties, we will assess the converse reduction of the ownership view to the capacity view. On this approach, the wealth of a person consists in her capacities, *some of which are conferred by the continuants she owns* (e.g., the capacity to travel fast conferred by the ownership of a car). One problem to be assessed here is that one’s belongings do not figure anymore in the definition of wealth, which has some odd consequences. For instance, a being that is destitute of all belongings, but which has the unlimited power to satisfy all its desires at will, would count as extremely wealthy on the view under consideration; one might, however, take such a being to be so powerful that wealth is superfluous for it. Conversely, a person who is deprived of most of her capacities, but who owns a lot of assets, should not be described as poor, but rather as a rich person who finds herself in a tragic situation. Intuitions like these pull us back towards ownership views.

(iii) The third, non-reductionist, way of reconciling the ownership and capacity views of wealth draws on a distinction between wealth and capital. There is no single accepted way of drawing the wealth/capital distinction in the literature. Some maintain that wealth includes natural resources, while capital is restricted to products of human activity. Others maintain that capital is productive, while wealth is not (Ricardo, 1817, 93-4; Piketty, 2013, 47; see Fisher 1897, 1904 for yet

other proposals). Building on a third use, we shall explore the hypothesis that wealth could be *equated with the owning of goods* (in accordance with the ownership view), while capital could be taken to consist in *the having of capacities* (in accordance with the capacity view). On this proposal, the capacities of a person are not articles of wealth, since they are owned; and the goods a person owns do not belong to her capital, since goods are not capacities. The key question then becomes: how is wealth (the ownership of goods) related to capital (the having of capacities)? This question will be at the heart of the third part of this subproject.

3. Wealth, capacities and production. If capacities are not pieces of wealth, how should we represent their relations to wealth? Three issues will be addressed in this area. (i) *How wealth increases capacities, and vice versa.* Gaining the ownership of a phone *confers* on a person the capacity to communicate at a distance. At the same time, even if capacities are not themselves goods, they may still increase the value of our goods. As Say (1851, xli) pointed out, of two persons owning the same good, the one who has the capacity to use it is wealthier than the one who lacks this capacity. The reason, we submit, is that capacities *confer* use-values on goods. One important task will be to describe properly in our ontology these reciprocal relations of conferral between goods and capacities. (ii) *Dead wealth.* Not all wealth confers capacities, however. Building on de Soto's (2003) concept of dead capital (Smith et al., 2008), we propose to define dead wealth as wealth that does not confer capacities. While de Soto's dead capital is restricted to cases where a lack of *legal* capacities prevents one from using one's goods (e.g., owning a house but lacking well-defined property rights to it), the concept of dead wealth we plan to delineate is meant to include cases in which we are powerless to use our goods because we lack capacities of *any kind* (e.g., legal but also physical, psychological or social capacities). One important instance of dead wealth is data that has been produced but is classified in idiosyncratic formats, thereby rendering it inaccessible to other digital systems or users. The chief goal of ontology-building is precisely to help solve this problem (Arp, Smith et al., 2015, ch. 1). Ontologies, on this account, help turn dead data into living data by conferring to human and digital systems the capacity to use it. The standard take is that dead wealth is simply not wealth. For instance, discussing the value of war materials after the 1918 armistice, Robbins (1931, 46-47) argues "that what at 10:55 a.m. that morning was wealth and productive power, at 11.05 a.m. had become 'not-wealth'". Given our hypothesis, by contrast, what has happened, in this scenario, is that living wealth has become dead wealth, which is still wealth. Why not, like Robbins, regard dead wealth as "not wealth"? The money that a very young girl may inherit makes her wealthier even before she gains the psychological and legal capacities to use it. The reason why dead wealth is still wealth can be made clear thanks to Vetter's notion of *iterated potentialities* (Vetter, 2015, 135-139; see subproject 1). Iterated potentialities are potentialities to acquire further potentialities. The hypothesis is that dead wealth is still wealth: for, despite its current uselessness, it is still *potentially* useful (see Walker, 1867, 18 for an early discussion of potential wealth). On this picture, turning dead wealth into living wealth is a genuine way to produce wealth, which amounts to actualizing some iterated potentiality. Various challenges for this proposal will have to be addressed. First, if turning dead wealth into living wealth indeed makes one wealthier, how are we, concretely, to factor dead wealth into a measure of wealth without putting it on a par with living wealth? Secondly, since the possible uses of a thing are innumerable, how are we to restrict what counts as dead wealth so as to avoid counting possible but unlikely uses of a thing? Thirdly, and relatedly, how can the disutility of some owned things (e.g., waste) be factored in on this account, which runs the risk of counting any increase in ownership as an increase of wealth, given its potential usefulness? Despite these challenges, we believe that the importance of dead wealth for the definition of wealth and economics at large has been underestimated. It is crucial, for instance, to understand the relation between wealth and

natural resources. Un-owned oil, under the present hypothesis, is “non-wealth”. Owned oil before the invention of the combustion engine was dead wealth. Owned oil after the invention of the combustion engine has become living wealth. Likewise, a recurring debate in the history of economics bears on the question of whether exchanges create wealth. Quesnay (1759) and Marx (1867, ch. IV, 178 sqq.) famously argue that they do not, on the grounds that they only redistribute existing goods. Others, however, argue that they do, on the grounds that exchanges, by improving the alignment of goods with subjective preferences, are mutually beneficial (see Massin & Tieffenbach, 2017, for references). Under the dead wealth hypothesis, exchanges may (also) contribute to wealth creation by better aligning goods with the capacities of their owners, thereby turning dead wealth into living wealth.

Work-package 3 (W3) will be led by OM with the help of doc2; other team-members will be involved in several aspects of W3. W3 will focus on the three research questions just outlined:

- (1) The relations between wealth, goods, and services (Year 1).
- (2) Definitions of wealth and capital (Year 2).
- (3) The relations between wealth and capacities (Year 3). (Visits by project-partners: Francesco Guala & Deirdre McCloskey.)

Dissemination of W3’s research results concerning (1)-(3):

OM’s publications, planned and underway (Massin, submitted; to appear a, b; Massin & Bermúdez, invited a, b).

Paper on the definition of wealth (OM).

Paper on conceptual foundations for an ontology of goods, wealth and capital (OM & postdoc).

Paper on dead wealth (KK & OM).

Paper on services and wealth (OM & doc2).

Doc2’s doctoral dissertation.

Annual conferences organized by team-members.

Special issue of the journal, *Metaphysics*, on ontology of economics, co-edited by KK, OM, & Raven.

Integration of W3’s research result into W1 (PROBO-ECON) and W4’s capstone projects.

Work-package 4 (W4) pulls together the results of W1, W2, and W3 achieved during Years 1-3 by means of several capstone projects to be completed during the final year of our project (Year 4). W4 will be led collectively by KK, OM, and the postdoc, but will involve contributions from all team-members. W4’s main research goals and outputs are as follows:

- (i) Finalization & integration of PROBO with existing ontologies & infrastructures (e.g., BFO & DOLCE).
(Project-partner visits: Barry Smith & Nicola Guarino).
- (ii) Interdisciplinary capstone conference on human production, products & by-products.
- (iii) Volume co-edited by KK & OM, tentatively entitled, *Human Products*, to be submitted to a reputable academic press.
- (iv) Paper defending a capacity-based approach to human-produced continuants (KK & OM).
- (v) Paper on productive actions (KK & OM).
- (vi) Completion & defense of doc1’s & doc2’s doctoral dissertations.
- (vii) Single- or co-authored publications by other team-members.

2.4. Schedule and milestones

The work-flow of our project can thus be represented as follows:

	YEAR 1	YEAR 2	YEAR 3	YEAR 4
RESEARCH FOCI	W1 (Ontology Building)			W4 (Ontology of Production, Products & By-Products)
	Preparatory work	PROBO-ART PROBO-ECON	PROBO	
	W2 (Artifacts)			
	Artifactual function, prototype-production	Digital Entities	Human vs. Machine Capacities	
	W3 (Economic Goods)			
	Wealth, goods & services	Definitions of Wealth	Wealth, Capacities & Production	
EVENTS	Ontology building training workshops			
	Weekly research events			
	Vetter Delley	Guala & McCloskey Delley	Raven Delley	Smith & Guarino Delley
	Annual Conferences			Capstone Conference
OUTPUTS	Issues of journal <i>Metaphysics</i>			Edited Volume
	Articles			
	Conference Presentations			
	PROBO-ART & PROBO-ECON		PROBO	Integration of Ontologies
	Dissertation prospectus & first chapter	Drafts of other chapters		PhD Dissertations

Throughout the project, weekly research events, such as a writing seminar as well as the Institute's colloquium series, will create regular opportunities for exchange between team-members and project-partners, and other researchers affiliated with the project. The project will have a dedicated website, to be maintained by the postdoc, with the help of doc1 and doc2, by means of which research results will be shared with interested parties.

2.5. Relevance and impact

This project will have a significant impact within philosophy by defending a novel conception of human-produced continuants which moves away from the prevailing emphasis on individual and collective intentions, and instead assigns a central role to the capacities of agents and their products. Our research promises to yield important new insights concerning a wide range of phenomena which may otherwise appear disconnected, including: material and immaterial (e.g., digital) artifacts; economic goods; as well as human and machine capacities.

The project's output will take the forms mentioned above in connection with (W1)-(W4): four organized conferences; an edited volume to be submitted to a reputable academic press; three edited journal issues; a significant number of co-authored and single-authored articles to be submitted to top-tier philosophy journals or volumes published by reputable editors (with some outputs, cited above, already in the works); oral presentations of these articles at local or international conferences before submission; two PhD dissertations; and three integrated mid-level ontologies, PROBO-ART, PROBO-ECON, and PROBO. The three ontologies will be implemented using state-of-the-art tools for ontology editing such as [Protégé](#), formalized in Web Ontology Language ([OWL 2](#)). They will be shared on the project's website and in popular ontology repositories such as the [Ontology Lookup Service](#), the [Industrial Ontologies Foundry](#), and the Behavioural and Social Sciences Ontology Foundry that is being developed by Hastings and colleagues to serve as a

platform analogous to the [OBO Foundry](#) but for the human sciences. These will facilitate reach and re-use of our ontologies by a much wider audience. Within the philosophy community, our strong connection with the International Social Ontology Society (ISOS) provides us with infrastructure for job advertisements, organization of research events, scientific exchanges and promotion of research results.

Ontologies are themselves digital products, which are directly usable within digital applications in ways that will lead to a broader impact for this project. By allowing digital indexing, they enable synthesis and mapping of the research landscape across a wide range of domains which can harness clearer descriptions of human-made products. Thus, in [behavioral science](#), there is a need to understand human interactions with products and their effects on human behavior; in the [environmental and energy systems sciences](#), there is a need for a better understanding of sustainability, energy production and associated economic impacts; in the [health sciences](#), the increasing digitalization of care is raising pressing questions concerning the health implications of these trends. In addition, ontologies can facilitate the development of knowledge-enabled software applications, e.g., those concerning product or wealth management.

We will pay particular attention to the public dissemination of our research results through our regularly updated project's website. To engage with a broader non-academic audience, we will ensure that our project and research topics are communicated to suitable media outlets in Switzerland and beyond.

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