Organisations and Variable Embodiments

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Abstract. How can organisations survive not only the substitution of members, but also other dramatic changes, like that of the norms regulating their activities, the goals they plan to achieve, or the system of roles that compose them? This paper is as first step towards a well-founded ontological analysis of the persistence of organisations through changes. Our analysis leverages Kit Fine's notions of rigid and variable embodiment and proposes to view the (history of the) decisions made by the members of the organisation as the criterion to re-identify the organisation through change.

Keywords. Social ontology, organisation, rigid embodiment, variable embodiment, organisational history, organisational decisions, organisational change.

1. Introduction

The importance of modelling organisations is nowadays widely acknowledged and recognised for at least a number of obvious reasons. Organisations accompany us from the cradle to the grave. We constantly interact with them—birth register offices, schools, hospitals, gas companies, telecommunication companies, cultural associations, sport clubs— in our everyday life as users or customers and this requires a certain degree of understanding of their processes. Even more importantly, we act within organisations— as workers in a firm or citizens in a state—and that may demand a deep understanding of their rules of functioning[1], to try either to use them to better fulfil our goals, values, and ideals, or to change those rules, if we deem them unfit or unfair.

Modelling organisations is a way to make their processes, dynamics, and norms more transparent, with the aim of making the interaction with them smooth and hopefully beneficial. As suggested by Dietz while talking about enterprise ontology [1], in order to be able to deal with the complexity of organisations, both a comprehensive theory and adequate methods of analysis are necessary. Of course, the same could be said about the ontological modelling of organisations. Along these lines, in this paper we approach a well-founded analysis of some central aspects of organisations, based on relevant philosophical investigations.

Many disciplines study organisations, ranging from sociology, philosophy, economics, legal and business studies, computer science, just to name a few. Roughly speaking, we could divide the approaches studying organisations with respect to their focus,

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[1]In general, in the paper we will use the term "rule" when referring to something which is codified and "norm" when we intend to include also non codified prescriptions.

which is usually either on their conceptual or their concrete aspects. While the former (e.g. [2], [3], [4], [5], [6], [1], [7]) assume a more functionalist perspective and are more concerned with explicit goals, formal structures and procedures, official rules etc., the latter (e.g. [8], [9], [10], [11], [12]) are more process-oriented and concentrate on situatedness, materiality, and practices of organisations.

This paper, which follows and extends previous work (see [13], [14], [15], [16], [17], and [18]), goes in the direction of providing a comprehensive account that keeps these structural and dynamic aspects together. In particular, our main interest here is in modelling the persistence of organisations—mainly structured, formal, and official organisations—through changes.

The paper proceeds as follows. In Section 2 we will discuss, in light of our previous work, the characterisation of the main elements of an organisation, both from a conceptual and static point of view and from a concrete and dynamic perspective. Section 3 presents Kit Fine's notions of rigid and variable embodiment and introduces the proposed account. In Section 4, we discuss the variable embodiment principle in the case of organisations and we show how the history of the decisions of an organisation is fundamental for its reindentification through time. Finally, Section 5 concludes the paper and indicates some possible future research directions.

2. Organisations and their elements

In this section, we will provide a general characterisation of the main elements of organisations, of how they are connected to one another and of how all such elements and their connections can change through time. Throughout the section, we will use the International Association for Ontology and its Applications (IAOA) as a driving example.

2.1. Organisations at a given time

Let's start by having a look at the IAOA at a certain fixed point in time, for instance the current moment. What are the elements that make up the IAOA? The first thing that comes to mind are its members: Michael, Laure, João Paulo, . . . , some are simply members of the organisation, while others may play particular roles, allowing them to have specific powers within the association, or to act on its behalf. The characteristics of these roles, e.g. what their players can and cannot do, what are their duties and responsibilities, how they are connected with the other roles, etc. are described in the statute of the association.

In the IAOA statute, we find the definition of many roles and sub-organisations. An example of the former is the role of president, who "calls and presides over ordinary and extraordinary meetings of the Executive Council" (duties) and " [. . .] has the legal authority of the Association to delegate tasks to the Vice-President or to other Members of the Executive Council" (powers). A sub-organisation is instead the Executive Council (EC), for which it is specified: how it is composed (by "a minimum of 5 and a maximum of 11 Councillors elected by the Meeting of the Assembly") and chosen among the members (requisite); it nominates the members of the advisory board and decides on requests of membership and on expulsions (powers), it must propose a budget and financial reports to be submitted to the assembly (duties) and has the responsibility to

ensure that the association complies with the statute. Roles have been characterised in [13] as concepts defined in a description, whereas in [15] we added the constraint that such description should be valid within the organisation.

Rules are also a central element of organisations; in the statute of the IAOA many rules are stated, including rules for membership: "In order to join the Association, interested parties must apply for membership [. . .]. Admission requests must be approved by the Executive Council" and decision rules "The Assembly approves motions with the favourable vote of a simple majority of the members". Rules of these kinds have been ontologically formalised in [18] and [19].

Other important elements constituting organisations are their purpose and the general tasks that will be carried out to achieve it. In the case of the IAOA, in the statute the purpose is defined as promoting interdisciplinary research and international collaboration on the themes of ontology and its applications.

Now that we have described all its main components, how could we describe a particular organisation at a certain point in time? In the example, how can the IAOA—as it is today—be described? We could hypothesise that it is described by a collection of persons in their roles, like Michael playing the role of president, Laure playing the role of councillor, João Paulo playing the role of member, kept together by a pattern of relations. We could add the statute, the roles, the organisational chart, the rules, etc. But if we take this to be an approximate picture of an organisation at a certain time *t*, what happens to it when it undergoes changes?

2.2. Organisational change

There are many changes that can affect an organisation during its lifecycle without making it cease to exist. The first simplest cases are changes affecting the players of roles: a new member can join the organisation, existing members can be expelled (or resign) and members can change their role. In the IAOA case, new members can be admitted at any time, provided that they follow the correct registration procedure and that the EC approves their request. Any member can also be expelled, if they violate the rules of the association or some external norm that applies also in the association as part of a wider organisation (e.g. national laws). Members can also voluntarily resign. Finally, members can change their role through time; for example, Laure has been councillor at a certain time, member at a later time and then councillor again. Also roles can incur changes through time. They can be added or eliminated, for example the IAOA could decide[2] to add a new role, like "membership officer", with specific requirements (being a member), powers (managing new members' registration) and duties (communicating requests to be approved to the EC); it can also decide to eliminate a role when considering it redundant, for instance by eliminating the role of secretary and deciding that all their duties will be carried out by each councillor on a rotational basis. Requirements to play a role can also be modified, the tasks associated with a role can be changed, by transferring some powers of a role to another. The structure of the organisation may also incur transformations, for instance by adding new sub-organisations with specific tasks, or by "flattening" the structure.

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[2]When we say "the IAOA could decide" of course we mean those who have been delegated via the rules in the statute to take the decision.

An organisation can change also from a teleological point of view. In the simplest case, the activities established at a point to attain the purpose can be changed, the IAOA could decide to launch an international PhD program to promote interdisciplinary research in ontology; or, it can change the purpose itself, by expanding it (promote interdisciplinary research in ontology and epistemology), restricting it (research in fuzzy ontology), or completely changing it (research in defeasible logic). As long as it is acknowledged and endorsed by the assembly, any of such changes is possible. If the "superior external norms" (for instance national laws) allow it, an organisation could also change from one type to another, as it would be the case if the IAOA changed from non-profit to business limited company[3].

All the changes listed so far presuppose changes in the rules of the organisation: those affecting the playing of roles, from membership to requirements to be appointed to specific roles, and the same holds for powers, rights and duties assigned to them, including actions (who can perform them and which decision they presuppose) and decisions, which are regulated both concerning who is allowed to take them and the procedures that are put in place (for instance majority voting or a weighted voting). All these rules can be modified and, more importantly, even the rules that prescribe how other rules could be changed. The statute of the IAOA, for instance, prescribes how these changes could be done: "For amendments of the present Statute at least three quarters of the Members must convene (physically or virtually) in an Assembly, and there must be a favourable vote of a simple majority of those present [. . .]". Given that organisations can incur all these changes, how can their essence be determined? How can they be re-identified through time?

In the following, we will leverage Kit Fine's theory of embodiment [20] to sketch an account able to represent the intertwined aspects—conceptual and concrete—of organisations and their perdurance through all changes they can undergo.

3. Organisations as embodiments

3.1. The embodiment theory in a nutshell

In [20], Kit Fine presented a theory about material things and how they are constituted by their parts. Fine uses the theory of *rigid embodiment* to characterise timeless parthood relations and *variable embodiment* to talk about temporalised parthood.

Concerning timeless parthood, Fine identifies wholes with their component parts plus the relation that keeps them together. The example he uses throughout the paper is that of a ham sandwich, which is composed of two slices of bread and a slice of ham standing in a specific relation, such that the slice of ham is located between the two slices of bread. If $a, b, c, \ldots$ are the components and R is the relation holding them together, the whole will be a new object "$a, b, c, \ldots / R$", where the R is taken to be different from $a, b, c, \ldots$ as it is what qualifies them. This new object is, in Fine's theory, a *rigid embodiment*:

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[3]Of course, this is a trickier case, as types could be considered as rigid and it could be necessary to dissolve the old organisation and found a new one, but this seems to depend entirely on external rules.

An object of this special sort will be called a *rigid embodiment*, since the "form" R is embodied in the fixed "matter" $a, b, c, \ldots$. Let us agree to designate such an object by the term "$a, b, c, \ldots / R$." The relation R will then be called the *principle of rigid embodiment*, and the operation by which a rigid embodiment is formed from the objects $a, b, c, \ldots$ and a relation R, the *operation of rigid embodiment*. [pp. 65-66]

Fine provides a list of postulates to describe the rigid embodiment operation; we report here those related to the issue of persistence. The first is an *existence* postulate, stating when a rigid embodiment exists:

(R1) The rigid embodiment $a, b, c, \ldots / R$ exists at a time t iff R holds of $a, b, c, \ldots$ at t. [p. 66]

The second is an *identity* postulate, stating when two rigid embodiments are the same rigid embodiment:

(R3′) The rigid embodiments $a, b, c, \ldots / R$ and $a', b', c', \ldots / R'$ are the same iff the state of $a, b, c, \ldots$ standing in the relation R is the same as the state of $a', b', c', \ldots$ standing in the relation R'. [p. 66]

Fine then moves to talking about *variable embodiments*, taking as example the water in a river. This expression can be understood in two ways: either the water that is in the river at a certain time, or the water that is in the river throughout time, meaning not the total amount of water that has flown in the river through time, but rather the water that is in the river at different times and that varies from time to time. The concept of variable embodiment is taken by Fine to apply to the latter case. Another example he mentions is that of the main pieces of a car (like the engine, the chassis, …) assembled in the manner characteristic of a car. According to Fine the pieces of the car can be substituted and the way in which they are arranged may change through time, with the car as a variable embodiment staying the same, notwithstanding the changes. So, the car as a variable embodiment is a sort of collection of the instantaneous assemblages of pieces that constitute the car at different times during its existence.

To define variable embodiments, Fine postulates a principle that picks up, at any time in which a whole object exists, the parts that constitute such object at that time. In the case of the river, it picks up, at any moment in which the river exists, the water that is in the river at that time. Hence, the definition is:

In general, we will suppose, given any suitable function or principle F (taking times to things), that there is a corresponding object standing in the same relationship to F as the variable water of the river stands to *its* principle. We call this object the *variable embodiment of F* and designate it by $/F/$. The principle F in $/F/$ will be called a *principle of variable embodiment*, the various objects picked out by the principle F the *manifestations* of the variable embodiment $/F/$, and the *operation* "$//$" by which $/F/$ is formed from the principle F the operation of variable embodiment. In contrast to the case of a rigid embodiment $a, b, c, \ldots / R$, the matter of a variable embodiment is not given independently of the form or principle, but is itself specified by means of that principle. [p. 69]

As a consequence, we can say that the principle of variable embodiment picks up, at every t, the rigid embodiment which is the manifestation of that variable embodiment at

t. Fine also provides postulates for existence and identity for variable embodiments and for their relationship with the rigid embodiments which are their manifestations:

> Where $f = /F/$ is a variable embodiment, we shall use f_t for the object selected by F at t, that is, for the manifestation of f at t. The postulates of existence [...] and identity are then as follows:
> (V1) The variable embodiment $f = /F/$ exists at time t iff it has a manifestation at t. [...]
> (V3) The variable embodiments $/F/$ and $/G/$ are the same iff their principles F and G are the same. [...]
> (V4) Any manifestation of a variable embodiment at a given time is a temporary part of the variable embodiment at that time (in symbols: $f_t \leq_t f$). [p. 70]

Both the relational principle R for rigid embodiments and the functional principle F for variable embodiments are conceptual and intensional, so in Fine's theory the identity criteria for material objects are intensional. What is left unspecified in Fine's account is *how* the principle of variable embodiment picks up the manifestations of a variable embodiment through time; in other words, he does not say *in virtue of what* we can say that $e = a, b, c, \ldots /R$ and $e' = a', b', c', \ldots /R'$ are both manifestations of the variable embodiment f. Fine just tells us that they are selected in virtue of F, but he does not tell us what F is.

Going back to the example of the car, if both the pieces of which the car is constituted (engine, chassis, ...) and the way in which they are assembled can change, what is this F that allows us to re-identify this car as the same car through time and changes? Fine seems to assume that each variable embodiment has its own principle, but maybe at this point it is legitimate to ask whether all these Fs have anything in common, or at least all the Fs of some kinds of objects.

In the next sections, we adapt Fine's account to the case of organisations and we reason about the possibility that the variable embodiment principles for organisations have something in common and can thus be used for re-identifying them through time.

3.2. *Organisations at a given time and rigid embodiment*

In [20], Fine develops his theory of embodiment for material things, but towards the end of the paper he claims that the theory can virtually be "capable of accounting for the identity of a wide range of different entities", including processes and abstract things. Apparently, then, nothing prevents us from applying the account to social and institutional entities which, indeed, seem to be prone to be explained by means of it.

We have stressed the fact that organisations are complex entities whose conceptual and concrete aspects are intertwined. In Section 2.1 we have described the fundamental components of organisations; the list included physical agents (role players), roles, purpose, tasks and rules; to these we could add other things belonging to at least some organisations, like buildings, premises, devices and what we take to be the "concrete" constituents of the embodied organisation. Now, let's take an organisation at a certain t: if, under the theory of embodiment, the current elements of the organisation can be seen as its components (the $a, b, c, \ldots$ of the $a, b, c, \ldots /R$ object), what keeps them together, the relational principle R, seems to be in our case the pattern of relationships holding within the organisation at t, including the *classification* relation holding between roles and play-

ers and the *definition* relation holding between rules and roles. The rigid embodiment $e = (a, b, c, \ldots / R)$ may then represent the embodied organisation at t.

At different times, either (some or all) the constituents, or the relational principle (the pattern of relations), or both can vary. Through these changes, we obtain different *rigidly embodied* organisations at different times.

In the IAOA example, assume that in different moments we change first the players of certain roles, then we change the organisational chart and at the same time the pattern of relations[4]; we could have three different rigid embodiments in three different moments. In 2010 we have certain members, certain roles etc.; in 2012 we have certain members (including now a new member Amanda), and the same roles and relations as before; in 2016 we have the same members as in 2012, but with an additional role, that of membership officer, and a new pattern of relations ($R' \neq R$).

- $IAOA_{[2010]} = Claudio, Leo, Peter, President, EducationCommittee, \ldots / R$
- $IAOA_{[2012]} = Claudio, Peter, Amanda, President, EducationCommittee, \ldots / R$
- $IAOA_{[2016]} = Claudio, Peter, Amanda, President, EducationCommittee,$
  $MembershipOfficer \ldots / R'$

If we take the rigid embodiment to represent the organisation at a certain time t, when we move to the variable embodiment, we can see how the changes that the organisation goes through are determined not only by abstract rules, but also by concrete decisions and actions. We shall focus on this point in the next section.

3.3. Organisational change and variable embodiment

So far, under the scope of the theory of embodiment, we can represent organisations at a definite time as rigid embodiments. But how can we represent an embodied organisation through time? If $IAOA_{[2010]}$, $IAOA_{[2012]}$ and $IAOA_{[2016]}$ represent how the $IAOA$ was embodied in three different moments in time, how can we represent the *variably embodied IAOA*, (let's call it $/F_{IAOA}/$)?

If we apply the theory of embodiment, there will be a functional principle F that picks up, at any moment t in which the $IAOA$ has existed, its manifestations, thus $IAOA_{[2010]}$, $IAOA_{[2012]}$, $IAOA_{[2016]}$ and many others. And how can we say whether $IAOA_{[2012]}$ and $IAOA_{[2016]}$ are manifestations of the same organisation, $IAOA$? Well, we can say that, if the principle that picks up $IAOA_{[2012]}$ is the same as the principle that picks up $IAOA_{[2016]}$ (in this case, if both are picked up by F_{IAOA}), then they are manifestations of the same organisation. Fair enough, but what is F_{IAOA}?

Moreover, take another (possibly heterogeneous) organisation, like the Italian Republic, do F_{IAOA} and $F_{ItalianRepublic}$ have anything in common? Do they have structural similarities? Some common foundational aspects? In Fine's account, the whole issue of the persistence of complex entities is encapsulated in the functional principle of variable embodiment, but the latter is like a black box.

In the next section, we will discuss some hypotheses for understanding the functional principle of the variable embodiment for the case of organisations.

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[4]These two changes do not need to be made at the same time, they could happen in different moments.

4. Organisations and their decisional history

A possible way to see the functional principle F applied to the organisational realm is like a mechanism that reconstructs the historical trajectory of an organisation through changes by picking up all its manifestations at every time in which it has existed.

Now, let's suppose that the time is discrete and we have two rigid embodiments that exist at two successive times t and $t+1$, let's call them e and e', respectively. Are there some constraints e and e' must satisfy to be manifestations of the same variable embodiment $/F/$, of the same organisation, at two successive points in time? Let's recall that, in the case of organisations, every element and the relational principle that compose the manifestations e and e' can change. However, on the one hand, the principle F cannot pick up any rigid embodiment whatever, as e' has to be a legitimate (in the context of organisations) evolution of e. On the other hand, although the organisation as it is at $t+1$ *depends* on the organisation as it is at t, it is not completely determined by it, since usually an organisation has a collection of actions available, all those that are permitted to it at t. Conversely, the organisation as it is at $t+1$ is consistent with different possible past courses of actions, even if not all.

Our proposal is to constrain the principle F on the basis of the history of the organisational decisions and actions. To illustrate in what sense an organisation is deeply characterised by its decisional historywe sketch a very simple model by means of the formal framework of *situation calculus* (ST) [21], which has been designed to represent the dynamics of systems.

4.1. Brief introduction to situation calculus

The main idea behind ST is that all the changes happening in a given system (organisation, in our case) are the result of (the execution of) *actions* that are usually represented by functions with some parameters. A possible history of the system is then determined by a sequence of actions and is represented by a first-order term called *situation*. The function symbol *do* allows for determining the successor situation, i.e., $s' = do(a, s)$ is the situation obtained by performing the action a starting from the situation s. The situation s_0 denotes the *initial situation*, i.e., the empty sequence of actions. The system is described in terms of a set of first-order predicates (and functions). To account for its dynamics, some of these predicates (functions), called *fluents*, have a situation term as last argument. For instance, $closeTo(x, y, s)$ represents the fact that the objects x and y are close in the situation s (but they could be quite far in another situation).

To axiomatise actions, ST assumes that they need some requirements to hold in a given situation, represented by *precondition axioms*, and that their execution affects the values of fluents, represented by *effect axioms*. $Poss(a, s)$ is an ST primitive that means that it is possible to execute the action a in the situation s. We will consider some examples of how actions can be axiomatised in the next few paragraphs. It is well known that ST suffers two important problems, namely the qualification problem of actions and the frame problem. We do not have space here to present the different possible solutions to these problems, the interested reader can refer to [21]. For our example on organisations, we consider the simple solution proposed in [21], which requires a *successor state axiom* and an *action precondition axiom* for each fluent of the theory. We illustrate this solution through the following example without introducing the general logical form of these axioms.

4.2. A simple example of modelling organisations by using situation calculus

We introduce a very simplified model of organisations that however sufficiently illustrates the mechanism of change through time that we are interested in. In principle, we can enrich the model by adding all the relevant aspects of an organisation that we have previously discussed. In this very simplified model, in addition to actions and situations, the domain contains two kinds of entities:

- *person*(p): "p is a person";
- *role*(r): "r is a role".

Furthermore, the state of an organisation is completely described in terms of the organisational chart that specifies the persons who play the roles in a given situation by means of the fluent[5]

- *plays*(p,r,s): "in the situation s, the person p plays the role r".

Our organisation can perform only two kinds of actions:[6]

- *enroll*(p,r): "enroll the person p in the role r";
- *unenroll*(p,r): "unenroll the person p from the role r".

They represent the decisional power of the organisation. We consider neither who performs the action, nor who took the decision. Basically, we take that it is always the whole organisation that decides and performs actions, but this model can be tuned to capture a number of decisional behaviours [18].

The action precondition axioms are:

- *Poss*(*enroll*(p,r),s) ≡ ¬*plays*(p,r,s)
  it is possible to enroll p in r if and only if p does not play the role r;
- *Poss*(*unenroll*(p,r),s) ≡ *plays*(p,r,s)
  it is possible to unenroll p in r if and only if p plays the role r.

These axioms introduce decisional constraints, i.e., the organisation can commit to a given action only when the required conditions are satisfied. In our case, the conditions concern only the organisational chart. More complex normative conditions can be introduced, accounting also for external (with respect to the organisation) constraints.

The effect axioms are:

- *plays*(p,r,do(*enroll*(p,r),s))
  after the action *enroll*(p,r) is executed in the situation s, i.e., in do(*enroll*(p,r),s), p plays r;
- ¬*plays*(p,r,do(*unenroll*(p,r),s))
  analogously, in do(*unenroll*(p,r),s), p does not play r.

These axioms represent the impact of the actions and decisions of the organisation in the system. Again we consider only internal impact, i.e., changes in the organisational chart.

The successor state axiom is:

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[5]For the sake of conciseness, we do not report the axioms that establish the kinds of arguments in predicates and functions, we just use different notations for the variables.

[6]Note that once the set of persons and roles is established, the set of actions is fixed.

- $plays(p, r, do(a, s)) \equiv a = enroll(p, r) \lor (plays(p, r, s) \land a \neq unenroll(p, r))$
  after the execution of the action a at s, p plays the role r if and only if a is the enrolling of p in r or p already plays r at s and has not been unenrolled from r.

The idea illustrated by this simple ST-model is that what characterises a particular organisation are: what holds at the initial situation s_0 and the specific sequence of actions executed by the organisation, i.e., its history. The model is not deterministic[7] in the sense that it is the organisation that decides the action to execute among the available ones in a given situation, i.e., among the actions that satisfy the preconditions. Here the decisional process is not explicitly represented, but a richer model could take into account the sequence of decisional actions needed to enroll or unenroll a person. Vice versa, starting from a situation, the execution of a given action always produces deterministic effects[8].

Assume, for instance, that at the initial situation s_0 the following holds:

- $person(J), person(P), person(L)$
- $role(Member), role(President)$
- $plays(J, Member, s_0), plays(J, President, s_0)$

That is, at s_0, John (J) is both a member and a president. Note that *person* and *role* are not fluents, i.e., all the statements involving these predicates hold independently of the situation. In particular, this means that the sets of persons and roles—as well as the set of actions $enroll(J, Member)$, $enroll(J, President)$, $unenroll(J, Member)$, etc.—are not dynamic, i.e. the domain is not affected by the actions.

Consider now $s_1 = do(enroll(P, President)), s_0)$, i.e., the first step of the history of the organisation is the enrollment of Paul (P) in the role of president. The only effect of this action is $plays(P, President, s_1)$. The successor state axiom guarantees that all other fluents do not change, i.e., $plays(J, Member, s_1)$ and $plays(J, President, s_1)$ hold. The organisation has then two presidents at s_1, namely John and Paul. The effect of the action $unenroll(J, President)$ performed at s_1 is that $\neg plays(J, President, s_2)$, i.e., at s_2 only Paul is a president. This organisation is then determined by what holds at the initial situation s_0 and by its history, namely the sequence of actions $[enroll(P, President), unenroll(J, President)]$.

Assume now to have a variable embodiment $f = /F/$. By using the above ST-model, we want to express the conditions that e and e' must satisfy to be two possibly distinct rigid embodiments of the same organisation. Note that in the domain of our model there are neither organisations nor rigid embodiments (of organisations). Concerning the first point, although our example models a single organisation, by embracing a multiplicativist approach, one could include several organisations as new individuals in the universe of discourse and ascribe specific intentionality and agency to them. Concerning the second point, our general idea is to rely on the correspondence between rigid embodiments and states established by the postulates (R1) and (R3′) introduced by Fine (see above). More precisely, we aim at mapping two successive manifestations e and e' of an organisation into two successive *states* of such organisation. A first difficulty is that the entities involved in e and e', i.e., the components of the organisation at t and $t+1$, may be different, as organisations are dynamic in terms of their components. In contrast, as

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[7]We refer to a notion of non-determinism and its relationship with agency as construed in [22].

[8]The non-deterministic aspect of the organisational life is due to the degree of agency of organisations, cf. [18,23].

already observed, the situation calculus being a first-order theory, its domain is static, e.g., the sets of persons and roles do not vary through situations, they are not affected by the executions of actions. To single out the potential components of an organisation at situation s, one then needs to consider the entities that are involved in the organisation at s. Since our fluents describe only the organisational chart, we assume here that, at situation s, the components of the organisation are the active persons and roles: a person p is part of the organisation at situation s when there exists a role r such that $plays(p,r,s)$ holds and a role is part of the organisation at s only when it is occupied, i.e. there exists a person p such that $plays(p,r,s)$ holds. Formally:

$$comp(x,s) \equiv \exists r(plays(x,r,s)) \vee \exists p(plays(p,x,s))$$

E.g., in our example, the components at s_1 are J, *Member*, and *President*. All the other "static" non-fluent propositions (e.g., $person(J)$ or $role(President)$) are not relevant for determining the components of the organisation.

We still need to identify the relations that connect the components in the rigid embodiments. We focus on relations that are describable only in terms of the fluent *plays* (plus identity), i.e., we ignore the predicates *person* and *role*. For instance, in the situation s_1, the relation R_1 that characterises the way the components of the organisation— namely, J, *Member*, and *President*—are connected is defined as follows (where p, r_1, r_2 are variables):

$$R_1(p,r_1,r_2) \equiv plays(p,r_1) \wedge plays(p,r_2) \wedge \neg(r_1 = r_2)$$

Given an ST-model of an organisation, we say that there is a *matching* between the state of the organisation at s and the rigid embodiment $a_1,\ldots,a_n/R$ when:

i. $comp(a_1,s) \wedge \ldots \wedge comp(a_n,s) \wedge \forall x(comp(x,s) \rightarrow x = a_1 \vee \ldots \vee x = a_n)$
$a_1,\ldots,a_n$ are all the components of the organisation at s; and
ii. $R(a_1,\ldots,a_n)[s]$ holds, where $[s]$ means that s must be added as last argument in all the fluents that appear in the definition of R.[9]

For instance, the state of our organisation at s_1 matches $(J, Member, President / R_1)$ because they have the same components and $R_1(J, Member, President)[s_1]$ holds, which is $plays(p,r_1,s_1) \wedge plays(p,r_2,s_1) \wedge \neg(r_1 = r_2)$.

Suppose now that our toy model exhaustively describes an organisation, i.e. assume, for the sake of the argument, that organisations are entities composed only by persons and roles linked by the *plays* fluent that can only enroll or unenroll persons. Furthermore, consider two situations s and s' such that the states of our organisation at s and s', respectively, match two successive *distinct* manifestations e and e' of the same organisation.[10] We state that the rigid embodiments e and e' can be two consecutive manifestations of the variable embodiment f only when there exists an action a such that $s' = do(a,s)$[11]. This means that, given the actions that the organisation can do (by taking into account the precondition axioms), the state that matches e' must be reachable (by taking into account effect axioms) starting from the state that matches e.

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[9]In our example we have only the fluent *plays*.

[10]The distinctness between manifestations could be defined in terms of the logical (non) equivalence of the corresponding states assumed by the postulates (R1) and (R3′).

[11]Notice also that, as for Fine's rigid embodiments, two states of two different organisations f and g may in principle coincide, i.e. f_t and $g_{t'}$ coincide (at the same or at different times), in case they have the same components linked by the same pattern of relations.

Notably, this constrain is not peculiar to our simplified model, it can be generally stated: two consecutive states of an organisation must be reachable by means of some permitted action. This view attributes to the decisions of organisations a fundamental role in establishing their identity, re-identification, and persistence through time. On the one hand, this constraint cuts off principles of variable embodiment for organisations with successive distinct manifestations that do not correspond to states reachable via an action. On the other hand, it suggests a re-identification criterion for organisations, a principle for characterising their evolution through time: the way an organisation is at time $t + 1$ is determined (*i*) by the way it is at t; and (*ii*) by the decisions (that comply with the rules the organisation is submitted to) and consequent actions taken at t.

To be expressed, this constraint requires a model of organisations where the permitted actions and the impact of their execution are taken into account. This indicates that organisations cannot reduce to collections of rigid embodiments or, more precisely, to the collections of their manifestations throughout their life. This is particularly relevant when there is not a univocal way to pass from a state of the world to another, when a state can be reached from an initial one by following different sequences of actions. In these cases, *contra* the postulate (V3) of Fine, *how* the manifestations are connected by actions, i.e. the specific course of actions undertaken by the organisation, is a fundamental aspect, due to their agentive nature that allows them to freely decide which action to perform. It seems then that no identity or persistence criterion for organisations can ignore this decisional aspect by focusing only on the manifestations.

In the context of the theory of Fine, a possible solution is to enable the variable embodiment to encapsulate the way in which the manifestations are connected by actions. For instance, the decisions taken by an organisation at t could be introduced among the components of its manifestation at t, while the principle F would exclude the cases where successive manifestations do not match these decisions (on the basis of the knowledge about actions). A second possibility is to move towards a sort of ST-model, i.e., to reduce an organisation to a pair $\langle e_0, [a_1, \ldots, a_n] \rangle$, where e_0 is the manifestation of the organisation at its establishment and $[a_1, \ldots, a_n]$ is the (maximal) sequence of its actions. By supposing to have enough knowledge about actions, one could then reconstruct, from e_0 and from the whole decisional history, all the manifestations of the organisation. Depending on the task, one or the other solution may come out as more adequate, but the crucial point is that they both represent organisations as developing entities, whose development is driven by agency.

5. Conclusion and future issues

In this paper, we discussed an account of organisations and their changes based on Kit Fine's theory of embodiment. We proposed a correspondence between (*i*) the states of organisations at a certain time and rigid embodiments; and (*ii*) the organisations through their changes and variable embodiments. Similarly to Fine's account, we have assumed a principle that allows to pick up states of the organisations that correspond to manifestations of the same organisation. Differently from Fine, who leaves the principle of variable embodiment undetermined, we have proposed the decisional history of an organisation—the actions that permit the transition between the states of the organisation—as fundamental to establish the identity of an organisation. That is, what "glues" together the

different states of an organisation and allows for understanding its persistence through time is its decisional history. This view has two important consequences: (*i*) in an organisation, everything can change (both its components and their relations), provided that changes happen on the basis of the powers that the organisation has at a certain time (that the preconditions for the actions for change are satisfied) and thus (*ii*) also actions and decisions are fundamental elements for the organisational identity.

The idea that history is one of the pillars on which the identity of organisations is based is not new in studies on organisational identity, although the notion of identity that these scholars are interested in is not the ontological one connected with persistence, but it is rather epistemological: they try to establish when some observers (be they members, other organisations, the public opinion . . .) recognise an organisation as being the same organisation through changes (see [24] and [25]).

Some scholars in management studies claim that the identity of an organisation depends on the ability to reconstruct a coherent history of the organisation. In such studies very often the term "history" is replaced by "memory", as in one of the pioneering work in organisational identity [26], which views organisations as information processing and interpretative systems based on the use of a common language and everyday social interactions, which use memory as a background for present and future decisions. In this view, it is thus very important to define the *retention structures* where memory is stored, the processes to acquire, store and retrieve memory and which have been the consequences of the events stored in memory, in order to be able to produce positive outcomes with present and future decisions.

The importance of storing memories[12] in organisations and in societies at-large has also been highlighted in social ontology by referring to documents [28], inscriptions and recording of memory traces [29], or mental files [30]. Independently of how and where the history or memory of organisations is recorded and stored, our focus here is on the constraints that the functional principle must satisfy in selecting only those rigid embodiments whose histories are consistent/coherent as constituents of the variably embodied organisation. Our approach offers a suitable explanation of how such *retention structures* are dynamically built while the organisation evolves.

It could be argued that, at any given time, many actions are available to an organisation to reach its successive state, so how does an organisation choose between the available options? Possible hypotheses are that such choices should be coherent with the goals or the values of the organisation. This is one of the possible lines of development of the present work.

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[12]Some more recent sociological literature seems to suggest that the identity of an organisation, more than on memories of the past decisions, should be based on experiential reconstructions of such memories operated by the members of the organisation, who use such reconstructions to build a narrative continuity between past and present. According to such studies—as, for instance [27]—such reconstructions lay the foundations of the *collective memory*, which is something more than the mere *collected memories* (the recordings of the facts or the traces stored in repositories or simply in the minds of the members), but it's something that shapes the organisation itself.

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