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Impact of meta-roles on the evolution of organisational institutions

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Abstract. This paper investigates the impact of changes in agents' beliefs coupled with dynamics in agents' meta-roles on the evolution of institutions. The study embeds agents' meta-roles in the BDI architecture. In this context, the study scrutinises the impact of cognitive dissonance in agents due to unfairness of institutions. To showcase our model, two historical long-distance trading societies, namely Armenian merchants of New-Julfa and the English East India Company are simulated. Results show how change in roles of agents coupled with specific institutional characteristics leads to changes of the rules in the system.

Keywords: Institutions · BDI · Agent-based simulation · Meta-roles · Cognitive dissonance

1 Introduction

Employing evolutionary methods to study economic change has attracted several scholars. For instance, Nelson and Winter proposed the idea that "organisational routines" are pivotal in the evolution of business firms (i.e. their role is similar to the role of the genes in biological evolution) [28]. Also, they suggested that "[metaphorically] [r]outines are the skills of an organisation." However, different scholars suggested various definitions of routines. For instance, Feldman and Pentland called "a repetitive, recognizable pattern of interdependent actions, involving multiple actors", a routine [16]. Routines have similarities with institutions (e.g. 'the rules of the game' [25]), in terms of their collective attributes [8] (i.e. they have rule-like conditions [23]). However, whether routines are subconsciously followed (they are simple rules) or they are open to amendments and changes (they are ambiguous rules) is subject of controversy [7]. Hodgson [23] criticised Nelson and Winter's [28] method and pointed to some shortcomings such as not considering 'birth' and 'death' in their method.

Also, in computer science, role/meta-role based frameworks were developed to facilitate modelling. For instance, Riehle and Gross [29] developed a role modelling approach 'to describe the complexity of object collaborations.' Also,

MetaRole-Based Modelling Language (RBML) was expressed in the Unified Modeling Language (UML) to describe patterns' attributes [18]. The CKSW (*Commander*–textitKnowledge–Skills–Worker) framework was proposed for meta-role modelling in agent-based simulation [27]. The idea of integrating roles and institutions is already studied in the context of multi-agent systems. For instance, nested ADICO refined Ostrom's grammar of institutions [13] by differentiating between roles (e.g. enforcer and monitoring agent) [19].

The BDI (beliefs-desires-intention) model is a cognitive agent architecture [9] with some extensions, including the BOID [10], EBDI [26] and the BRIDGE [14] models. This architecture was employed to model agents' cooperation in institutionalised multi-agent systems [5,6].

In light of earlier studies, this paper integrates agents' meta-roles [27] in the BDI architecture and also employs the theory of planned behaviour TPB [17] to model different facets of beliefs. The integrated model is used to investigate how dynamics in agents meta-roles may lead to the evolution of organisational institutions. Meta-roles in this work are modelled using the CKSW framework that helps modellers to decompose agents in a society based on the characteristics of their roles [27]. The coupling of the CKSW framework within a BDI architecture is investigated in the context of rule-making and -following (how rules are established, interpreted, and followed).

2   An overview of the extended BDI architecture

This extended BDI cognitive architecture is shown in Figure 1. It can be observed that there are two separate blocks, a left block called '*Events*' and a right block called 'Cognitive architecture'. The Events block represents the events an agent perceives from the environment (e.g. information collected from peers). The *Cognitive architecture* block represents an agent's cognitive decision-making components. Note that when an action is performed by an agent, it will be an input event for those agents interested in that event in the next iteration. A brief description of the four high-level components is provided below. It should be noted that the main focus of this paper is on the addition of *Role* component to the BDI architecture (highlighted in green in Figure 1).

- **Roles:** An agent has a set of roles in society regarding established institutions (e.g. agents make those institutions or they monitor their implementations). An agent's role impacts its beliefs, based on individual and social experiences (e.g. it personally may find the rule unfair). We discuss this module in more detail in Section 3.
- **Beliefs:** To model beliefs, we are inspired by the idea of different belief components of TPB [17]. This component indicates an agent's perception about the rule and the support the rule has. In other words, an agent has its own internal belief about the rule, and also the perception about the social support for that rule (e.g. rebuking the rule), and an estimation of what an organisation meant by the rule (e.g. consequences of minor violation).
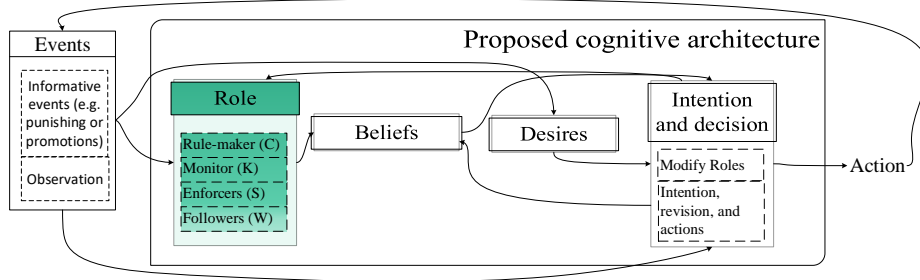
Fig. 1. Proposed cognitive architecture for this model.

– **Desires:** Agents have different desires, such as an agent's goals and ideal preferences.
– **Intentions and decision:** An agent's intentions for an action and its decision about the final action is formed in this module. The decision results in an action which can be a modification of beliefs and roles or only performing a task.

3   Meta-roles and role dynamics

To model agents' roles and their interactions we use CKSW meta-roles [27]. Note that CKSW is a generic model and since this paper concerns the rule-making and rule-following context, we reinterpret those roles in this context as follows:

– *Commander* (**C**): This role is empowered with ultimate authority [27]. In this context, they are the agents who are permitted to *make or revise rules*.
– *Knowledge* (**K**): This role concerns the *know-what* aspect of a society [27]. In this context, these are agents who *monitor and report* the *suspicious activities* of others.
– *Skills* (**S**): This role concerns agents who are known for their skills in society (*know-how*). Unlike knowledge, skills are difficult to communicate and much more so to apply [27]. In the rules context, those agents that have the skills to interpret the rules judge reported agents' activities.
– *Worker* (**W**): These agents perform basic jobs that do not require specialist skills [27]. In this context, they are agents who do not formally collaborate in monitoring, establishing, or interpreting the rules (i.e. the rest of agents).

We also consider two categories of roles, *formal roles* and *informal roles*:

– Formal roles: these roles are defined based on the agent's position in an organisation (one of CKSW meta-roles).
– Informal (internalised) roles: these roles are unofficially and self-assigned (e.g. based on values) by agents such as monitoring, and reporting suspicious

behaviours of other agents to managers. These are the role(s) that an agent may perform in addition to its formal role (one or more out of the CKSW meta-roles).
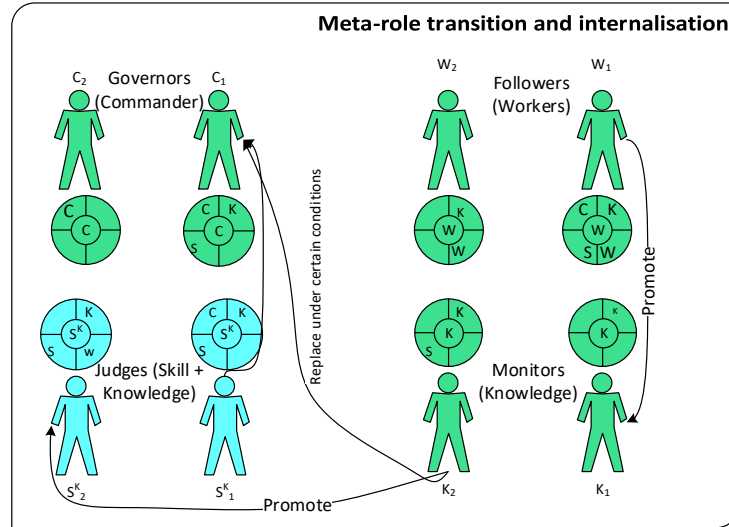

Fig. 2. Transition of formal meta-roles and internalising informal meta-roles — the circles indicate roles that an agent really performs (including internalised roles), and the bigger fonts indicate more involvement in such a role. The arrows indicate the possible transitions in a society.

Figure 2 depicts how an agent's meta-role may evolve[3]. In this example, a worker (say clerk) of an organisation may be promoted to a higher rank after demonstrating competence for such a promotion (say to a manager, a knowledge-based role). If the manager has relevant education, skills and experience, it can be promoted to an even higher position. In these positions, the manager may be responsible for interpreting the situation and deciding about who to fire or hire (i.e. promotion from Knowledge role to the role of a judge (skill) — represented as S^K in the figure). Under certain conditions an agent (Knowledge or Skill) can be promoted to director role (i.e. to the Commander). Note that judges (highlighted in blue) might not be explicitly present on an organisational level for various reasons (e.g. sometimes legal cases go to international courts).

In Figure 2, the initials for formal roles are indicated on top or bottom of each agent (e.g. K_1) and the list of all roles for an agent (i.e. informal and formal roles) are shown in circles placed near the agents. The font sizes of initials inside these circles indicate the involvement level in such a role, with larger fonts involving more involvement. The involvement is influenced by the ability of an agent to

---

[3] Note that most times agents are downgraded for economic issues or bad performance of agents, and this downgrading can be considered as an extension of this model.

perform a role, as well as the perceived importance of performing such roles from an individual agent's perspective. For instance, some worker agents may adopt additional informal roles in a company (e.g., k for agent W_2). Some worker agents may monitor other agents or they may have a charismatic personality and informally establish rules (i.e. norms) which are executed by the help of other agents (see internalised roles of W_1). Another example is the case of a knowledge agent who may adopt the informal judging role voluntarily (note the addition of S to K_2's formal current role K). Note this agent could adopt the monitoring role for various reasons (e.g. to help stabilise the rule or to weaken the rule-following by not reporting the violators).

Another example is the commanders who may also take additional roles such as K and S (e.g. C_1). They may take some informal roles to influence rule change. For instance, even though they may establish a rule, they may feel that they do not have the obligation to follow them and so they may overlook them, hence impacting rule-following for the whole society. These examples described above show how formal and informal roles can shape rule changes in an organisation.

4   Simulation, algorithms, and parameters

In this section, first, we discuss the underlying assumptions of this simulation. Then, we provide an overview of two historical societies studied for simulation, namely the English East India Company (EIC) and Armenian merchants of New-Julfa (Julfa). Then we briefly discuss the aspects of these societies that are of interest for us and the simulation procedures used to represent their agents' behaviour in the simulation context.

4.1   Assumptions

In societies, the rules that exist may not be honoured by agents. Although, the agents know the existence of such rules, they don't follow them and the agents justify this behaviour through the resolution of cognitive dissonance. *Cognitive dissonance* is defined as tensions formed by conflicts between different cognitions (for instance, one likes to smoke, but loathes to get cancer) [3]. These tensions lead to creating some justification for taking one action (quit smoking or continuing). This idea was used to attribute workers' productivity to cognitive dissonance regarding fairness of institutions [2]. In particular, studies showed that procedural justice (having fair dispute resolution mechanisms) increases public law obedience and cooperation with the police [32]. Also, underpaid or overpaid persons alter their efforts put forth on the system (e.g. efforts or voluntarily performed tasks) to make the system fairer for themselves [1]. In this work, we consider that agents justify the need for rule change (or don't follow rules), because they need to resolve this cognitive dissonance (i.e. they justify not following rules, or the reason to keep following the rules).

4.2   Societies

As stated earlier, in this paper, we investigate two long-distance trading societies, namely Armenian merchants of New-Julfa (Julfa) and the East India Company (EIC). The two societies were contemporaneous and shared the same areas for trading products (e.g. the EIC managers granted Julfans permissions for using the EIC infrastructures [4]). Also, both societies faced principal-agent problem [24] — the dilemma where the self-interested decisions of a party (agent) impact the benefits of the other person on whose behalf these decisions are made (principal).

Armenian merchants of New-Julfa (Julfa): Armenian merchants of New-Julfa were originally from old Julfa in Armenia. They re-established a trader society in New-Julfa (near Isfahan, Iran) after their forced displacement in the early 17th century [22,4]. They used commenda contracts (profit-sharing contracts) in the society and also used courts to resolve disputes [22,4].

The English East India Company (EIC): During the same time, the EIC (AD 1600s-1850s) had a totally different perspective on managing the society. The EIC faced a high mortality rate due to environmental factors in India. EIC paid fixed wages and fired agents based on their own beliefs about their trading behaviour. Furthermore, EIC's trading period covers the English Civil War (1642–1651), which led to inclusion of some of the senior mangers on the board of directors and granting permission for private trade to the employees (i.e. trading activities for individuals' self-interests).

In both of these societies agents' meta-roles changed over time. More precisely in EIC, a mercantile or trader agent (W) after gaining experience was promoted to a managerial position to monitor other mercantile agents (K). Also, in EIC, after the English Civil War, managers had the opportunity to be part of the board of directors (C). In Julfa, the promotions took place based on the ageing of the family members (i.e. agents got promoted from one meta-role to the other gradually). Additionally, in Julfa mercantile agents (W) and heads of families (C) formed the courts (S). In this model, we use the EIC dynamics in organisational meta-roles (i.e. promotion of agents) to make the two systems comparable. Note that this change in dynamics decreases the opportunities for Julfans to revise their rules. However, we know that the rules were deeply honoured by Julfans [4].

Environment: These societies had different mortality rates. On average an EIC agent died before the age of 35 due to harsh environmental circumstances [20]. Julfan traders did not face such a situation [4] and the closed trading society of Julfa would have collapsed under a high mortality rate [30].

Fairness: Another difference between the two historical long-distance trading societies is associated with their payment schemes for employees and the adjudication processes (i.e. use of courts for resolving disputes about suspicious behaviour). EIC rarely employed an adjudication process (e.g. agents were fired based on their performance because of suspected cheating), and the agents were paid low wages [21]. However, in Julfa a mercantile agent was paid based on his performance [4]. Julfans had adjudication processes to resolve disputes, which

considered available evidence [4]. Though Julfa appears to be fairer than EIC in terms of payment, total fairness can be questioned — for instance, in the Julfa society, the family wealth and trade was managed and controlled by the eldest brother [22]. This rule deprived younger ones from managing their own share of capital.

4.3   Algorithms

In this subsection, we discuss the procedures employed to simulate role changes within the two societies. The simulation model is split into four distinctive procedures. The first procedure models the societal level of simulation, including creating an initial population and staffing (hiring new mercantile agents) to create a stable population. The second level describes procedures for *mercantile agents'* (W) decision-making and learning the system's parameters. The third level covers the decision-making and learning procedure associated with managers (K). The last procedure is the meta-algorithm that sequentially executes the aforementioned algorithms and updates appropriate parameters. In this algorithm, agent meta-roles may change and the opportunity for institutional dynamics is provided (i.e. promotion of K agents to C and changes in institutions).

Algorithm 1: Societal level set-up and initialisation

/* Intialise the system starting with $iteration \leftarrow 0$.   */
1 Create 500 new agents with $status \leftarrow new$, random personality aspects, and random parameters
2 Assign appropriate roles (i.e. mercantile, managers, and directors) to created agents
/* n = deceased and fired agents (mercantile agents and managers) in the previous iteration.   */
3 The most experienced mercantile agents get promoted to a managerial role
4 Create n new agents with: $status \leftarrow new$, $Experiene \leftarrow 0$, and randomly initialise parameters
/* Perceived environment and fairness for inexperienced agents.   */
5 $PEnvironment \leftarrow RandomUniform(0,1)$
6 $Fair \leftarrow RandomUniform(0,1)$

Algorithm 1 shows how the societal level of the system is simulated. In iteration 0, the system is initialised by creating 500 new agents with random parameters (line 1). The roles are assigned to created agents (about 2% directors, 5% managers, and the rest mercantile agents).[4] The organisation hires and promotes agents to sustain the number of agents per role — i.e. replaces deceased agents (lines 3-4). The rest of the algorithm is executed only for inexperienced agents (i.e. new recruits). An agent has a completely random understanding of the system's characteristics (lines 5-6).

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[4] These numbers are inspired from the numbers in the EIC [20].

Algorithm 2: Mercantile agent's algorithm (for meta-role W)

    /* Update parameters for new recruits.   */

1 **if** $Status = New$ **then** Set agent's parameter using Algorithm. 1

2 **if** $Experience > 3$ **then**

      /* Update role and the decision to perform private trade.   */

3   **if** $Dissonance(Fair) < DissonThresh$ **then**

         /* Agent stops monitoring violations.   */

4   Remove K from voluntarily performed roles

5   **if** $\Big((Fair < thresh)$ **or**

         $(\dfrac{No.\ PrivateTraderFriends}{No.\ Friends} < JustifThresh)\Big)$ **then**

         /* Agent decides to perform private trade.   */

6 $PrivateTrade \leftarrow OK$

7   **end**

8   **end**

      /* Agent voluntarily collaborates in monitoring.   */

9   **if** $Dissonance(Fair) > DissonThresh$ **then** Voluntarily perform K

10 **end**

    /* learning;   */

11 **if** $Experience > 3$ **then**

      /* Reporting observed violations;   */

12   **if** $Voluntarily\ performing\ K$ **then**

         /* The agent reports some of the cheaters observed.   */

13   Agent reports connections who impose more costs on the organisation than his tolerance (internalised S).

14   **end**

15 **end**

16 Learn parameters and adjust the beliefs about rules

17 $Experience \leftarrow Experience + 1$

18 **if** $Rand(1) \leq MortalityProbability(Experience + 15)$ **then** Die

---

Algorithm 2 shows the procedure associated with mercantile agents' decision-making process. Note that in this algorithm $\#Rnd(x)$ indicates a random number generated in the interval $(0, x)$. As stated earlier, if the status of the mercantile agent is new, he goes through an initialisation (see Algorithm 1, lines 3-4). Furthermore, experienced mercantile agents decide on their participation in monitoring by considering cognitive dissonance incurred (based on their perception of institutional fairness and dissonance toleration). They also decide on performing private trade with respect to the perceived fairness and their friends who perform such trades (lines 3-7). If the mercantile agent has enough experience and has already decided to collaborate in monitoring, he helps the system to identify violators, based on his interpretation of a fair action (lines 8-9). Finally, the mercantile agent updates his perception of system parameters (e.g. fairness of the society), increases his experience, and may die (lines 10-12).

Algorithm 3 shows the procedures associated with managers (i.e. monitoring agents (K)). A manager creates a set that consists of reported violators with unacceptable violations (i.e. he tolerates violations to some extent, see line

---

Algorithm 3: Manager's algorithm (for meta-role K)

```
/* Manager reports (and eventually punishes) a number of employees
   who violate the rules of the organisation beyond its tolerance
   level. We call the threshold TolPunish.                          */
```

1 $PotPunish \leftarrow$ employees with violations more than $TolPunish$

2 if *The number of members of PotPunish > MaxPunish* **then**

```
    /* The manager has a limit for the number of agents he can punish
       called MaxPunish.                                            */
```

3   Punish $MaxPunish$ out of $PotPunish$ that have the most violation

4 else

5   Punish all $PotPunish$ members.

6 end

7 $Experience \leftarrow Experience + 1$

8 if $Rand(1) \leq MortalityProbability(Experience + 15)$ **then** Die

---

1). Note that the manager reports about the violators and punishes a certain number. If the number of violators exceeds a certain threshold, he punishes the worst violators (lines 2-3). Otherwise, all the violators are punished (lines 4-5). Finally, the agent's experience and age increase, and the agent may die (lines 6-7).

Algorithm 4: Meta algorithm

```
/* Intialise the system starting with iteration ← 0.               */
```

1 Create 500 new agents with $status \leftarrow new$ and random parameters with appropriate roles

```
/* Call algorithms in an appropriate sequence.                     */
```

2 repeat

3   Run Algorithm 1

4   Run Algorithm 2

5   Run Algorithm 3

6   **if** $iteration = 70$ **then**

7   Update board of directors (C) with new managers

8   **if** *majority support private trade* **then** legalise private trade and reduce wages

9   **end**

10 $iteration \leftarrow iteration + 1$

11 until $iteration = 250$

Algorithm 4 is the main algorithm that calls the other procedures. In iteration 0, the system is initialised by creating 500 new agents with random parameters. The roles are assigned to created agents (2% directors (C), 5% managers (K), and the rest are mercantile agents (W)), and they have 0 years of experience (line 1). Then, 250 iterations corresponding to 250 years, containing specific steps (lines 3-9) are performed (250). The first step is to run the societal algorithm (i.e. Algorithm 1, line 3). Then the algorithm associated with the mercantile agents is run (i.e. Algorithm 2). Finally, the manager's decisions are made

using Algorithm 3 (line 5). When the simulation reaches the year that some of the managers in the EIC (who started as mercantile agents) are promoted to the board of directors (i.e. consequences of the English Civil War, iteration 70), a decision about permitting (or legalising) private trade is made (lines 6-8).

4.4   Parameters

In this subsection, we discuss the important parameters employed in the simulation (see Table 1), along with the reasons for choosing specific values for them. Note that we used 250 iterations to reflect the longevity of EIC (it was active with some interruptions and changes in power from 1600 to 1850). In Table 1, column 'Name' indicates the names of parameters, column 'Comment' shows additional information if required, column 'Distribution' indicates the probability distribution used for these parameters, and column 'Values' indicates the values of parameters estimated for the two societies. Note that these parameters can be modified to reflect other societies.

Table 1. Parameters associated with the model

Variable name	Comment	Distribution	Values
Fairness	Unfair : Fair	Constant	$-0.4 : 0.6$
Perception of environment and fairness of system		Uniform	$(-1, 1)$
Thresholds	Dissonance Environment Fired agents	Uniform	$(0, 1)$ $(0, 1)$ $(0, 0.3)$
Monitoring	Boolean	Bernoulli	0.5
Permission for private trade	Percent of joined managers who agreed to change	Constant	70%

Fairness: Note that as discussed earlier, Julfa had fairer institutions than the EIC. We set system fairness values to 0.6 and -0.4 for fair and unfair societies respectively. We believe that neither of these two societies were totally fair or unfair (e.g. EIC managers justified the firing of agents that indicates there has some effort towards fairness).

Perceived characteristics: Because of lack of prior experience, the new agents have a totally random understanding of social characteristics.

Thresholds: These are the numbers that reflect an agent's tolerance of different aspects and characteristics of the system. All these thresholds are generated at random except for firing. For the proportion of fired agents, we assume that a manager would fire 30% of the suspected employees.

Monitoring: In the model, a recruit may voluntarily decide to participate in monitoring — we use a random boolean generator to represent this.

Permission for private trade: In this simulation, we assume that permission is granted if more than 70% in the board of directors agree to such a decision (i.e. 8 out of 11).

Furthermore, we parametrise the agents' learning as follows. Agents discount information using a weight of 30% for the past. This reflects the importance of recent information for agents.

5   Results

In this section, we describe the simulation results considering *four* different combinations of two characteristics, namely a) environmental circumstances and b) fairness of institutions. With two different values for each of these characteristics, four combinations are possible (see Table 2).

Table 2. System specification based on different characteristics

Characteristics	$E_0 F_0$ (EIC)	$E_0 F_1$	$E_1 F_0$	$E_1 F_1$ (Julfa)
Environment	✗	✗	✓	✓
Fairness	✗	✓	✗	✓

The configurations (i.e. societies) are identified by the first letter of the characteristics, namely E and F that are representatives of the **e**nvironmental characteristic of (E) and **f**airness of the institutions (F), respectively. A tick indicates that the society possesses such an attribute, and a cross indicates the society does not possess such an attribute. In this table, we gradually change characteristics of the EIC ($E_0 F_0$) to get closer to Julfa ($E_1 F_1$), to examine their effects on the success of these societies. We utilised *NetLogo* to perform our simulations [33]. We also used 30 different runs for each set-up and then averaged their results. Finally, note that the patterns observed in simulation results are compared to the patterns reported from the EIC and Jufla, because we had access to the qualitative data.

5.1   Permissions for private trade

Table 3 presents the percentage of simulation runs (out of 30) where the permission for private trade was granted (see row "Permission granted"). Note that this change in rule (granting of permission) happened due to changes in agents' meta-roles where a mercantile agent progresses to the board of directors (and advocates the decision to permit private trade). As can be seen from the results, both unfair societies (F_O) had higher percentage of runs where the private trade is permitted ($> 50\%$), although with a large difference (93% and 57% respectively). In fair societies, none of the runs resulted in private trade being approved. This result mirrors the evidence from Julfa. In Julfa, mercantile agents (W) and peripheral managers (K) were the ones who eventually ran the family business (C). Also, mercantile agents and managers made decisions regarding violations and acted as juries in certain courts [4]. The aforementioned situation, combined with keeping private trade illegal [22], indicate that this rule was so-

cially accepted.[5] Also, we know that in the EIC, the permission for private trade was granted once the managers had the opportunity to be part of the board of directors[15].

Table 3. Percentage of runs where private trade was permitted (out of 30 runs).

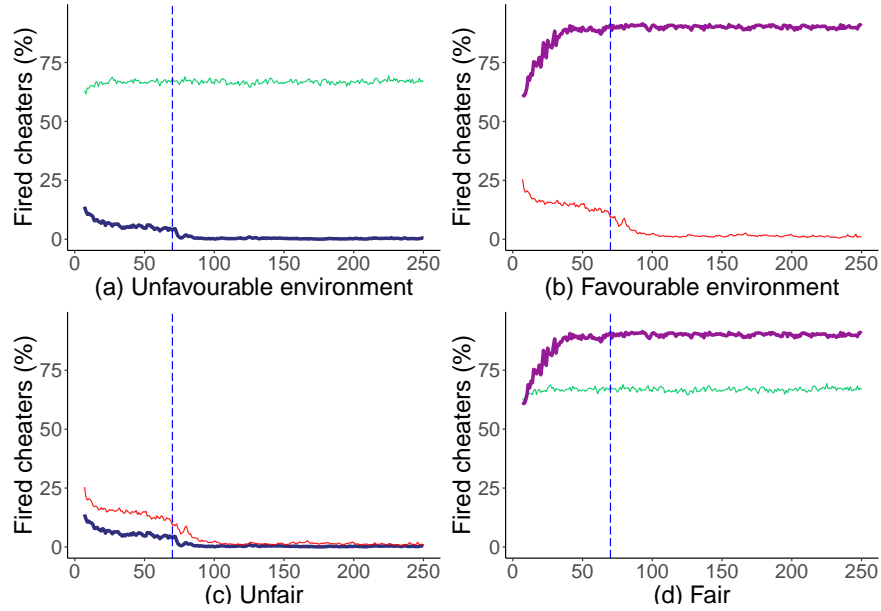| Societies	Permission granted for private trade
E_0F_0 (EIC)	93%
E_0F_1	0%
E_1F_0	57%
E_1F_1 (Julfa)	0%

Fig. 3. Monitoring strength and firing in simulated societies.

5.2   Fired violators (monitoring strength)

Now we discuss the impact of aforementioned two characteristics on the monitoring strength of the system (see Figure 3). Figures 3a-3d present the percentage of the cheating agents fired. In these figures, the y-axis indicates the percentage of fired cheaters. As can be seen, the most fired agents belong to society E_1F_1 and then E_0F_1. These indicate the importance of fairness of institutions on the system's monitoring strength.

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[5] Because in none of the simulation runs of Julfa the permission was granted, we believe that using a similar dynamics to Julfa would not change the results

This impact that we see in Figure 3 is a consequence of two informal roles performed by agents, namely a) mercantile agents (W) that monitor and report suspicious behaviours (internalised K) to managers (formal K), and b) managers (K) who interpret rules based on the situations and tolerate some behaviours (S). For example, managers who think the system isn't fair, may not report the cheating behaviour of agents (agents who are involved in private trades). And these same managers who become a part of the board of directors allow for these private trades to happen legally (but with the reduction in wages further, though). Also, in organisations with unfair institutions, after granting permissions for private trade (year 70), agents' collaboration in monitoring the cheaters (for theft etc.) decreases. Note that the evidence for interpretation of the rules can be found in EIC managers' correspondence[6]. Also, these results mirror the evidence of rare cheating and successful monitoring mechanisms in Julfa [4] and the popularity of cheating and collusion in the EIC [11].

6   Discussion and concluding remarks

This study has presented an extension of the BDI cognitive architecture to investigate its interaction with agents meta-roles. Also, using this extension, the study has investigated the impact of a combination of a) dynamics in agents' roles and b) the institutional characteristics (i.e. mortality rate and fairness) on organisational rule dynamics (i.e. change of rule). As the role of individuals changes (e.g. W to K), their beliefs formed based in their previous role impacts their new decisions. Finally, our study has used the evidence from empirical studies to simulate two historical long-distance trading societies, namely Armenian merchants of new Julfa (Julfa) and the English East India Company (EIC) and has demonstrated what may cause rule changes (i.e. role change and institutional characteristics).

The simulation results mirrored historical evidence. It has shown that the fairness of institutions is a pivotal characteristic to drive their stability (i.e. avoiding revisions in rules) and in facilitating agents' collaboration in monitoring each other's behaviours. These results (i.e. changes in rules and weak monitoring and reporting) mirror concerns in the modern context about the division of "rules into the two categories of rules-in-use and rules-in-form" [31]. For instance, it is noted that rules-in-use (followed rules) in some provinces of Canada might have been rules-in-forms (unfollowed rules that do not have any effect on behaviour) in others [31]. There exist some obstacles in a law in becoming a rule-in-use [12]. An instance of this obstacle is the activities of monitoring agents who interpret the law differently and thus hamper its effectiveness (e.g. through not monitoring violations) and hence can aid the formation of new rules similar to what has been observed in results from Table 3 and Figure 3.

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[6] For instance, in the early years, some managers defended mercantile agents' private trade by stating: "if some tolleration [sic] for private trade be not permitted none but desperate men will sail our ships" [11].

A future extension of the study, will involve detailed examination of the interaction between other modules of the cognitive architecture presented in Figure 1. Also, the simulation can be extended to take account of other characteristics of these historical societies, such as the personalities of agents, to provide a more fine-grained model.

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