A Case Study in Model Selection for Policy Engineering: Simulating Maritime Customs

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Abstract. The progress of containers through customs is more often an exercise in negotiation rather than a structured queuing process. As soon as a regulatory process involves negotiation, corruption becomes a factor. Studies by the Organization for Economic Co-operation and Development (OECD) and other organizations reveal that customs corruption is not easily combated by policy changes. Simulation of potential reform policies in the maritime customs context can provide insights for decision makers. In this paper we present a work-in-progress case study of simulation technique selection for modelling social complexity in the domain of maritime customs. We give evidence (1) to the applicability of a methodological approach that includes evaluation and reasoned selection of a modelling paradigm, and (2) to the applicability of agent-based simulation.

Keywords: model selection, process modelling, maritime customs, corruption, multiagent-based simulation.

1 Introduction and Motivation

Container shipments, according to the World Shipping Council, account for 60 percent of international sea-based trade by value. Competitive advantage is gained by properly managing and optimizing container flows through ports. The inspection of container contents and application of regulations and tariffs is a significant part of the import-export process. We study deviations from published maritime customs processes with the goal of using simulation as a tool in policy engineering. The domain is important not only because of the scale of maritime shipments worldwide, but also because of the deleterious impact of corruption, especially on the disenfranchised [56]. Given that corruption can enter the process whenever there is opportunity for human actors to negotiate [55], what simulation techniques can we leverage to assess the potential impact of reform policies that might be applied?

This modelling question is important because the choice and application of paradigm impacts the quality of the solution to the domain problem under study,

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the ease of solvability, and the scope and validity of insights that can be obtained. Given the socio-technical questions in our domain of interest, methodologies from two fields are pertinent: social sciences [22] and logistics [26]. Complex systems theory, agent-based modelling (ABM), and classical operations research (OR) are among the techniques applied to a range of problems in container logistics, port management, and policy analysis in our domain of interest (for ABM, e.g., [27, 38]). We are not aware of research that specifically studies the simulation of maritime customs processes in order to quantify the effect of reform policies.

The literature contains a number of surveys of methodologies (e.g., [40,54,12, 13,20,34]), which form the lens for this paper. We contribute to the methodological question by highlighting our experience with the selection of a modelling and simulation paradigm; we provide a data point for the discussion of best practices in fitting simulation techniques to the domain problems under study.

The methodological meta-approach we explore, derived from that of Terán [54], can be summarized as: (1) Identify the scenario/system to be simulated, and the goals of the simulation exercise; (2) Make an initial methodological choice; (3) Collect data necessary for model-building; (4) Review the model and language choices in light of the data; (5) Design and build simulation; (6) Run simulation to examine potential policy decisions; analyze and interpret the results; (7) Collect data on the fit between the selected techniques and the problem under consideration, and validate the model and results; and (8) Apply the conclusions to policy issues in the scenario/system. As can be seen, there is an emphasis on examining earlier steps in light of later steps and reconsidering decisions based on the progress of the process. We expand on these steps through this paper, and report our completion of the first four steps.

In summary, this paper details a work-in-progress case study of simulation technique selection for modelling social complexity in the domain of maritime customs. We give evidence (1) to the applicability of a methodological approach that includes evaluation and reasoned selection of a modelling paradigm, and (2) to the applicability of agent-based simulation.

2 Background and Problem Analysis

Whenever a process has the opportunity or obligation for human actors to negotiate, the possibility of corruption arises. The World Bank defines corruption as "the misuse of public office for private gain" [55]. We distinguish between (1) *routine* corruption (e.g., bribes for normal or expedited completion of processes); (2) *fraudulent* corruption (e.g., tacit or explicit collusion to reduce fiscal obligations); and, the least common but important, (3) *criminal* corruption (e.g., bribes offered to permit a totally illegal, lucrative operation).

While a corrupt act may bring local gain for one actor, the negative repercussions of corruption hang upon institutions, societies, and nations. These include impact upon [32,47,56]: poverty, tax evasion, political stability, democracy and rule of law, national competitiveness, and (especially for customs) distortion of trade figures. Further, corruption reinforces disenfranchisement and hinders development, being "one of the most serious barriers to overcoming poverty" with

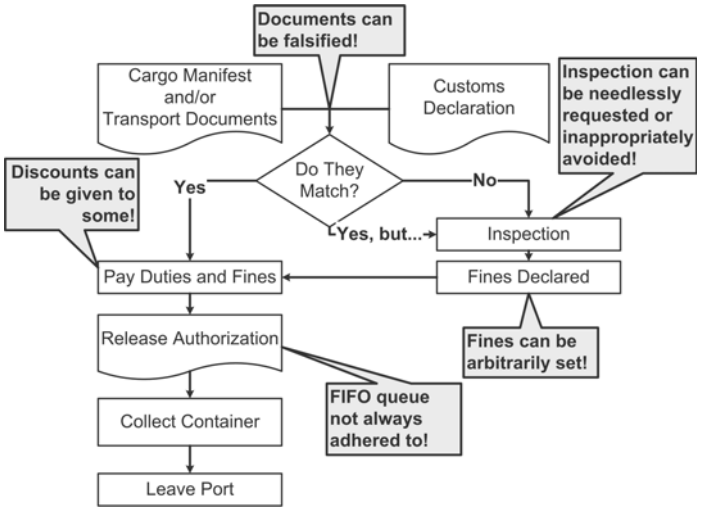

Fig. 1. An archetypal import process. Some opportunities for deviations from the published process are highlighted.

a strong correlation between perceived corruption and national per capita income [56]. However, as Langseth [35] points out, it would be "unrealistic and cost-prohibitive to attempt to eliminate corruption completely. ... Draconian anti-corruption programs, moreover, can have a negative effect on personal freedoms and fundamental human rights if regulations translate into excuses for public officials to become increasingly abusive toward the citizenry."

While eliminating corruption is not reasonable, reducing corruption is a common policy objective. Unfortunately, corruption is elusively difficult to fight. Whereas "strategies based on investigation and sanctions ... can be effective in regulating a situation of low corruption and preventing its further development", localized punitive or incentive-based policies "cannot correct a situation of widespread corruption" writes Hors [32]. The same report notes, based on lessons from three case studies, that "a re-engineering of procedures that leads to an important reduction of the opportunities of corruption should be at the core of the strategy." Complicating matters is the challenge of forecasting and comprehending the potential impact of policy changes. This recognized, even the most careful policy analysis and selection is not sufficient. Studies find that policy reform measures can only be successful if properly set within the national and institutional environment, driven by political will, sensitive to stakeholders at various levels, and part of a continuous improvement process [32, 2].

In order to counter established, widespread corrupt practices, a deeper understanding of the processes in which corruption features is required, together with a deeper understanding of the corrupt practices that occur, within the broad socio-political, socio-economic, governmental and cultural situation [49].

This need for understanding provides the motivation to our study. We posit that simulation can bring the measure of situated understanding sought.

Customs is defined as "the official department that administers and collects the duties levied by a government on imported goods" (Oxford English Dictionary [OED]). The process of moving a container through customs is primarily based on a match between shipping documents (e.g., bill-of-lading) and customs documents (e.g., manifest). If this match is made and the shipper/consignee are considered trustworthy, then the container may proceed following the payment of standard duties. If there is not a match, or should the container be randomly selected, then the container becomes subject to search and may see the leverage of additional duties or fines. The Organization for Economic Co-operation and Development (OECD) notes, particularly for developing countries, that customs revenue is a significant component of public finances, but that customs efficiency is often hampered by widespread corruption, creating "a major disincentive and obstacle to trade expansion" and leading to "disastrous consequences in terms of national security and public finance" [32].

Policy efforts led by the International Monetary Fund (IMF), OECD, World Customs Organization, and World Bank have focused on reducing trade barriers, reforming trade procedures, and building 'cultures of integrity'.

Fig. 1 shows some possible deviations from an archetypal customs import process. These include inaccurate, incomplete, or fictitious documentation; under- or over-inspection; inaccurate value estimation; waiving true fines or imposing additional fines; and delaying or expediting certain containers. In some situations, a whole grey 'parallel customs' system evolves (reported for Bolivia [18]).

Negotiation is the most common entry point for non-standard behaviour within customs processes [33]. The study of negotiation is multi-faceted, including political science, economics, policy research, psychology, and computer science. Turan et al. [57, 52] report on emerging efforts to unify research in behavioural and computational (including agent) communities. While the maritime customs domain holds a rich vein of research in the dynamics of bargaining situations, our objective is not to dwell deeply on the negotiation itself—framed as utilities, internal (affective) states, reasoning, and observable behaviour [57]—but rather to capture inter-actor negotiation within the customs process in order to study policy engineering questions.

3 Case Study: Selecting a Modelling Paradigm

We adopt a methodological meta-approach derived from the work of Terán [54], comprised in full of the ten steps explained below. Our simulation modelling case study stems from work in progress: we have completed the first four steps, and we progress with the fifth step. Terán distinguishes four levels of language in Multiagent-Based Simulation (MABS): (1) cultural or natural language, (2) modelling and theoretical paradigm, (3) modelling language, and (4) simulation programming language. We incorporate these four levels of language as we move through the following steps in the selection of a modelling paradigm.

1. **Identify the scenario/system to be simulated, and the goals of the simulation exercise.** Our aim is to study non-standard behaviours in maritime customs and the impact of policy reforms upon those behaviours.
2. **Make an initial choice of modelling paradigm.** We chose agent-based modelling for its promise in capturing the practices of actors that interact via negotiation *(modelling fit)*, a perception of *ease of implementation* in considering alternative policies, and insights on emergent behaviours (*explanatory power* for systems/process re-design). Moreover, we judged that MABS offers the potential to predict the impact of individual policy reform measures as well as to explore the effects of process re-engineering.
3. **Collect data to fuel abstraction and model-building.** We undertook a series of stakeholder interviews alongside a study of published processes. Note that the choice of paradigm (Step 2) has some bearing on the type, volume, and quality of data needed to create the model. Having chosen to model inter-actor negotiations richly and at the micro-level, we sought data sufficient to construct and validate an agent-based model.
4. **Review data and re-evaluate model and language choices.** While standard processes could be documented with some confidence, non-standard practices were related only anecdotally and from the literature. We reconsidered the option of a lower-fidelity model and traditional Monte Carlo simulation.
5. **Design and build simulation.** Outside the scope of this paper is a description of the MABS that we are constructing, based on the validated modelling decisions.
6. **Run simulation to examine potential policy decisions.**
7. **Analyze and interpret results.**
8. **Collect data on the fit** between the selected technique and the problem under consideration; possibly **revise the model, or even the methodological choice.**
9. Once the results have been validated and considered reliable, **apply the conclusions to policy issues in the scenario/system studied.**
10. **Seek to generalize conclusions to other problems or domains.**

The outcome sought from a rigorous process of selection of modelling paradigm and simulation technique is reliable and generalizable conclusions from the simulation. Two themes help achieve this outcome. The first theme is the ongoing re-examination of earlier steps in light of later steps, and reconsideration of decisions based on the progress of the process. The second theme is the principled, multi-level validation of methodological choice, model abstraction, and results [53]. We now turn to a detailed description of our work as related to Steps 1–4.

3.1 Step 1: Identify Target System and Simulation Goals

Sect. 2 explained the domain of customs and the problems situated around corruption in customs. The goal of our simulation is analysis of policies designed to combat corruption. To this end, the areas where new policies may be applied (or old policies enforced) range broadly [55, 35, 33, 32]: (1) computerized

data systems, (2) auditing, (3) sanctions, (4) role separation, (5) Customs Officer wages, (6) declaration and monitoring of assets for Customs Officers, (7) training, (8) culture of integrity (e.g., Code of Ethics), (9) legislative reforms, (10) legal reforms, (11) tax and tariff reform, (12) simplification of administrative procedures[1], (13) increased accountability and transparency (e.g., process documentation), (14) public awareness, (15) regular stakeholder meetings, (16) independent complaints authority, and (17) media freedom.

Principled means are required to evaluate and compare policy measures. From the literature (e.g., [36]), from reflection upon published measured data available, and from what interviewees said, we formulated the following metrics to assess evaluation of policy measures for import-export processes: (1) end-to-end time for an item to clear customs, (2) time deviation from desired date of receipt (usually, delay), (3) average tariff rate, (4) cost for an item to clear customs, including any corruption costs, e.g., bribes, that can be quantified, (5) percentage of items receiving electronic approval, (6) number of steps in the published process (a measure of transparency), (7) number of deviations from published process, (8) cost per deviation (are a lot of little deviations as bad as one big deviation?), (9) percentage of customs revenue diverted, i.e., lost to the government, (10) cost of enforcement, and (11) amount of change in a re-engineered process compared to a current process.

3.2 Step 2: Choose Initial Modelling Paradigm

In the second step of our methodological meta-approach, we selected an initial modelling paradigm. To assess the 'quality of fit' between a selected modelling or simulation technique and the problem domain (e.g., customs), problem instance (e.g., corruption), and study questions (e.g., competence of a variety of policies in mitigating corruption), we designated the following set of criteria, which provide a checklist for the choice of methodology. They are: (1) **Modelling fit**: how well does the modelling paradigm suit the (abstracted) system to be simulated? (2) **Cognitive fit**: how well does the modelling/theoretical paradigm suit the thinking of the modeller? (3) **Explanatory power**: how well can the simulation developed answer the study questions? (4) **Ease of implementation**: how well does the implementation language suit the model to be implemented and the questions to be asked? (5) **Computational tractability**: how readily can the simulation be performed?

Our initial methodological choice was influenced by the idea that corruption is a phenomenon that emerges. This influence comes from the recognition that regulations or policies are rarely established with the intent of *encouraging* corruption. On the contrary, published customs regulations are designed to regulate the flow of legal goods while capturing government revenue from duties. Nevertheless, corruption patently exists and is endemic in many locations. As such, we sought a modelling paradigm that could exhibit emergent behaviour, driving us quickly to agent-based models (ABMs).

[1] Significant as "systems and procedures [evolve] to maximise the number of steps and approvals—to create as many opportunities as possible for negotiation" [32].

The advantages of agent-based models are argued to include [3, 22]: (1) "descriptive realism ... natural system boundaries" [17] (*modelling fit* between the system studied and modelling paradigm and modelling language); (2) flexibility, ease of modelling (*cognitive fit* between natural language, and modelling paradigm and modelling language); (3) heterogeneity and adaptive behaviour at the micro level); (4) emergent behaviour at the macro level; (5) scalable/parallel computation; (6) some accessible tools (but see [23]), i.e., ease of implementation; (7) explanatory insights, especially into non-equilibra behaviour, social or spatial networks, and analytically intractable systems [3]; and (8) visual and intuitive nature for interpretation and public dissemination.

On the other hand, the disadvantages of ABMs are commonly recognized as [5,37]: (1) interpretation of the simulation dynamics (ABM are opaque: in some ways explanatory power is limited), (2) replication of results, (3) generalization of the results (including robustness of results), (4) validation of the implementation from bugs, and (5) extraction of an analytic model, if relevant.

Leombruni [37] is among those who argue that these disadvantages can be overcome. Agreeing, Hamill [23], an experienced policy adviser, nonetheless adds "To persuade policy advisers to adopt [ABM] there needs to be a clear benefit in terms of the output." Although the case for the value of agent-based simulation in policy analysis is made well by Dignum et al. [13,14], Hamill finds "The policy areas and questions that would benefit from ABM need to be identified."

A methodology for multiagent-based simulation consists of seven steps [6, 17, 11, 12] (for policy analysis, see also [34, 14]), which might be argued to hold beyond MABS: Abstraction, Design, Inference, Analysis, Interpretation, Application, Conclusion. The meta-approach we follow, outlined earlier, thus wraps very similar steps with methodological selection and re-evaluation.

The problem studied, while embedded into a social context and highly influenced by organizational, cultural, and social factors, does not fit exactly into any of the paradigmatic models for agent-based social simulation identified by Marietto et al. [40]; the closest match is *socio-concrete models*. Rather, simulating negotiation in maritime customs may be better characterized not as a social simulation per se, but as simulating social complexity—the structure and norms of what is and is not considered acceptable in the realm of customs processes, and the micro-macro link between (emergent) actor behaviours and policies applied to the system.[2] Our objective is not so much forecasting (as in economics) or optimization (as in traditional OR) but understanding of collective behaviours. In purpose, our simulation sits between *Mediative* and *Generative* [1].

Alternatives considered were simulation based on dynamic systems, classical OR techniques, and statistical aggregate analysis. In the interest of forthrightness,

[2] In the taxonomy of Davidsson et al. [12], the domain is 'social system and organizations'; the end-user is 'scientists' and, perhaps, 'policy makers'; the purpose is 'prediction' and 'analysis'; the simulated entity is 'living'; the number of agent types is a small finite number; the structure is peer-to-peer, hierarchal; agents communicate; the input data is mostly artificial; the present maturity is 'conceptual proposal'.

however, we acknowledge our predisposition to MABS. The following four reasons are largely behind this predisposition.

First, the naturalness of modelling inter-agent communication. We are modelling human actors negotiating, usually at a peer-to-peer level, for which ABM is well-suited. Second, a perception of ease of implementation: modelling and implementation environments are readily available. Third, sought explanatory power for systems/process re-design. The documented success stories of MABS speak of its efficacy [22]. Fourth, the established track-record of MABS in diverse domains coupled with the weakness of alternative methodologies, especially when studying complex, value-driven, human socio-technical problems [13, 34].

An additional factor in our decision was that agent-based models have been successful in port management and container shipment (e.g., [38,26]), and agent-based simulation has been successful in port stakeholder analysis (e.g., [27]) and policy analysis in transport (e.g., [8]). Agents have also been used to study corruption, as we survey below in Sect. 4.

3.3 Step 3: Data Collection

We chose to study the Port of Beirut, Lebanon, due to its regional prominence and its proximity to our institution. The port handles some 900,000 TEUs per year (out of 500M worldwide), with annual revenues in excess of $150M. It processes 80% of imports into Lebanon, as well being a significant transshipment point for Syria and beyond [7]. Further, anecdotal and published reports indicate a number of exotic practices [45,39,10,46], which may likely be considered to be a superset of practices elsewhere. As a country, Lebanon is in the bottom third of the Transparency Index [56], with a 2009 score of 2.5/10.

The objectives of the initial data gathering phase were to characterize the domain and the processes of interest, and to elicit structural, environmental, institutional, and behaviourial knowledge necessary to build a MABS. Further, the data and its interpretation informs the next step in the methodological process, namely the re-evaluation of the selected models and techniques.

Three sources of information provide the basis for abstraction and modelling in MABS [17]: (1) observation and data collection from the target system, (2) bibliographical review (i.e., theories), and (3) domain experts.

Target observation. Regarding the first source, the only data obtained directly from the target system is published statistics that are available for import-export figures in various jurisdictions. It comes as no surprise that we have, to date, been unable to collect empirical data by observation (e.g., sampling containers and following their progresses through the process); in view of the sensitivity of questions in the domain, this kind of empirical study is unlikely.

Bibliographical review. The bibliographical review yielded more data. While jurisdictions differ in their regulations and procedures, nearly all ports have similar import-export processes [42]. Fundamentally, the processes depend on a match of paperwork between manifest and declaration. Nearly all ports have an IT

Table 1. Actors identified in maritime imports process at the Port of Beirut

Owner	Excise officer
Owner's agent	Head of Excise
Freight forwarder	Customs broker
Shipping company	Longshoremen
Vessel captain	Customs warehouse employees
Clearance Agency officer	Port security staff
Customs Agency officer	Recipient (consignee)
Inspection officer	Police officer
Head of Inspection	Customs Investigation and Audit officer

system of some sort, which includes a maritime container standard [4]. The widest differences between systems are seen in taxation schemes.

We examined documented processes at the Port of Beirut, the Port of New York/New Jersey, and the Port of Rotterdam. For reasons of space, and due to the broad similarities, we describe only the Port of Beirut; for the others, see [4].

Fig. 2 summarizes the administrative hierarchy and depicts the import process at the Port of Beirut. Initiated in 1993 with its first release in 1998, *NAJM* is the Lebanese automated customs clearance IT system. *NOOR* is the online portal to NAJM. Over half of all declarations are electronic, and automatically verified containers, known as 'green line declarations', account for the majority of declarations (in the reported statistics). We note that one result of these kind of IT systems, as in ports worldwide, is a separation of roles.

A primary role in the container clearance process is that of *freight forwarder*—a company that manages and organizes shipments for others, sometimes consolidating smaller shipments. Data from freight forwarder companies (e.g., [9]), provided valuable context and insight into port procedures.

To give context to customs practices, we also examined published research on the broader socio-economic and cultural environment [29, 50, 39, 49]. Lebanon's culture is shaped by both Arab and European influences. Lebanese like Arab culture is collective (IDV 38) and has high power distance (PDI 80) and moderately-high uncertainty avoidance (UAI 68), but the Lebanese are famously entrepreneurial. Likely because of the 1975–90 civil war, the Lebanese distrust government and place a low value on obeying rules [45]; the economic and societal context is laissez-faire coupled with strong family and, for some, religious values.

Domain experts. In order to form a more robust picture of standard and non-standard practices at the port, we conducted semi-structured, exploratory interviews with stakeholders associated with the Port of Beirut, including customs brokers, freight forwarders, and those familiar with Customs Officers. For reasons of privacy and given the sensitivity of the topic, we refrain from identifying the interviewees with the statements given.

The actors in import-export processes are listed in Table 1. Our interviewees, when feeling able to speak with some freedom, reported a systemic norm of deviations in import-export process. Customs Officers in practice have greater discretion than their job description states. It was considered routine to engage in

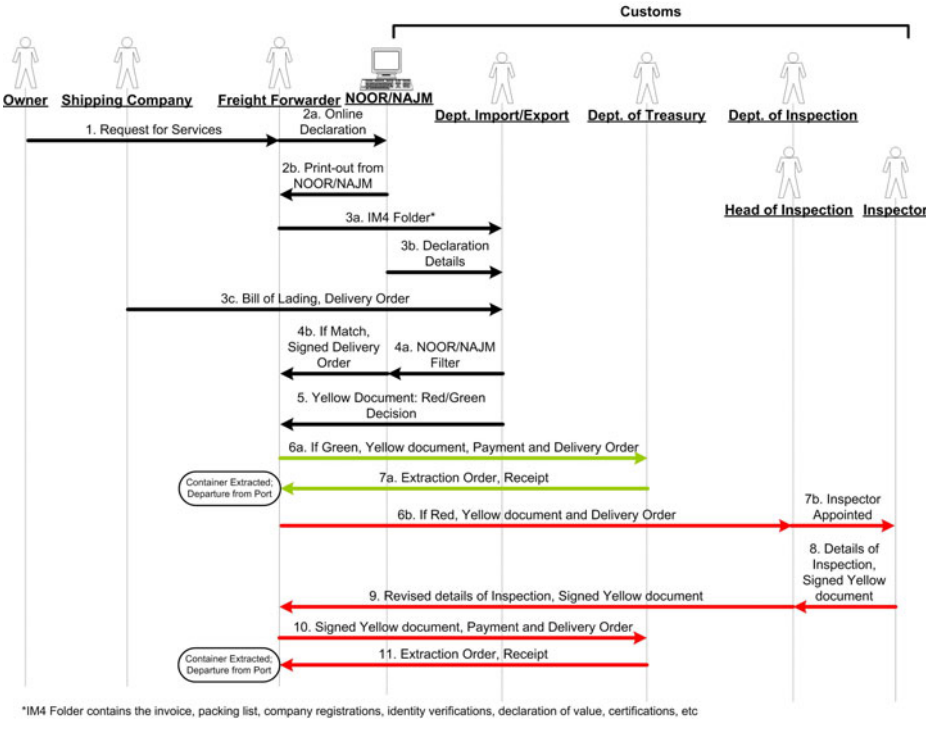

Fig. 2. Simplified customs import process at the Port of Beirut

'wasta' [39]—exploitation of influence, political (or other) power, connections—or to offer a bribe or a 'baksheesh'—a widespread practice "(in parts of Asia) [of] a small sum of money given as alms, a tip, or a bribe" (OED).

Non-standard practices reported fall into three categories. First, deviations based on the relationship between actors, where there is no obvious monetary or physical bribe. Relationship levers in negotiation can arise from family connection (nepotism), political tie (patronage), or favour owed. Second, deviations may be based on monetary considerations, where there is a tangible bribe, whether cash or gift, or a debt forgiven. Third, negotiation levers also include threats or extortion, whether physical, financial, or reputation-based.

Our interviewees noted that these deviations from stated practice stem from three sources: discretionary interface between actors, networks of accomplices, and lack of efficient controls. One story is illustrative: a container of household goods was expedited on the basis of an iPad (new and difficult to obtain in Lebanon at the time) that was gifted to a freight forwarder, who in turn used his personal relationships to garner the "good will" of the Customs Officers. Neither party saw this behaviour as non-standard because it fell outside the domain of the IT system and within the domain of standard social/cultural behaviour.

At the instigation of the IMF and other international organizations, Lebanon restructured its customs law and tariffs in 2000 [7, 36]. Despite the IT systems,

the legal restructuring, and political will (or, at least, words) [46], our fieldwork correlates with reported statistics that corruption is endemic in Lebanon (e.g., [45,39,56]), at least in maritime imports. This only underscores the challenge of determining effective policy measures to fight corruption.

3.4 Step 4: Re-evaluate Model and Language Choices

We reconsidered the suitability of ABM by returning to the quality of fit metrics introduced in Sect. 3.2. To mitigate anchoring bias from our initial choices, we sought the input of experts outside the MABS community. Specifically, we presented the preliminary conceptual design of our MABS at the 2010 Annual Meeting of the Institute for Operations Research and the Management Sciences (INFORMS). The feedback obtained provided us with a new perspectives on alternative modelling paradigms for the domain problem under study.

Among traditional OR techniques is Monte Carlo simulation. In such an approach, the agent's reasoning is modelled as a form of stochastic process. The probability distribution over possible actions the agent could take is estimated. For example, at a given opportunity to offer a bribe, does the freight forwarder offer money or not? Indeed, as Axtell [3] points out, when the system being simulated is stochastic, with the behavioural equations known, then MABS can be seen as a type of Monte Carlo simulation. Although accurate empirical data is unlikely, given the problem being studied, our fieldwork encourages us that sufficient, reliable information can be obtained to design and validate a MABS [1]. Further, we believe that ABM allows high-fidelity modelling of inter-actor negotiations, and allows agent behaviours that are heterogenous and adaptive. Hence, only if insufficient data is available to construct and validate an ABM, then a lower-fidelity model and traditional Monte Carlo simulation may fit better. Second, we had concern that a methodology based on stochastic processes risks being too simplistic, since we are trying to capture complex processes and, ultimately, adaptive human negotiations [13]. Third, we hold that the behaviours exposed in our field studies are naturally modelled as entity-level interactions. Fourth, traditional OR techniques are found to be inadequate for complex, value-driven, socio-technical problems [34]. Finally, we hold that MABS can bring insight into processes as well as providing values for global metrics (e.g., mean end-to-end clearance time). Specifically, it allows us to see the change in behaviour(s) at the micro, agent level.

This analysis convinced us to continue with MABS given its capabilities for micro- (agent behaviour) and macro- (emergent phenomenon) level analysis. Implementation of the simulation (Step 5: Design and Build Simulation) is our ongoing work.

4 Discussion and Related Work

Earlier sections introduced the literature on customs and corruption, and on agent-based modelling. Here we briefly review methodological approaches and agent-based models of customs and corruption.

Wilkenfeld makes an analysis of the applicability of simulation or experimental techniques to the study of international negotiation and mediation [58], wherein the studies arise from the political science literature.

As noted, there are a number of surveys of (agent-based) modelling methodologies (e.g., [40, 54, 12, 13, 20, 34]). Our presented meta-methodology is adapted from that of Terán [54]. His work distinguishes four levels of language in MABS; in generalizing, we observe that much of Terán's analysis can apply to other simulation techniques besides MABS. Focusing on the social sciences, Terán observes the opportunity to make language selection decisions, "likely at the modelling level", in order to obtain a set of analytic and applicative inferences that together yield an interpretative conclusion.

Edmonds and Moss argue for complex models in agent-based social simulation under the slogan of 'Keep It Descriptive, Stupid' [16]. Whether models are developed from a simple or descriptive paradigm, we suggest the benefits of reflecting critically on the modelling methodology and languages. Moss [41] contrasts verification of such models according to economic and behavioural schools of thought. Hassan et al. [25] argue for data-driven agent-based simulation. They propose that available data is used in design of the model and its initialization, as well as for validation of simulation results. We further suggest that data can aid the choice of simulation methodology.

Ghorbani et al. [21] develop a framework for agent-based social simulation design. The MAIA methodology is intended to be encompassing and generic, by combining the comprehensive Institutional Analysis and Development (IAD) framework from institutional economics and social science, and the OperA agent-based software development methodology that includes organizational aspects. MAIA has attraction for the design of MABS in the customs domain.

Hammond [24] develops an agent-based population model in an effort to explain shifts in corruption levels. Corruption is modelled as a simple, game-theoretic repeated interaction on the micro level. In a tax-evasion domain, endogenous shifts in global corruption levels are observed as emerging.

Like us, Duggar and Duggar [15] are interested in analyzing the implications of reform policies aimed at reducing corruption. They study collusion and extortion in a hierarchical bureaucracy consisting of honest and dishonest officials, concluding a relationship between organizational form and the potential for corruption. They find that in 'competitive' organizational cultures, when peer relationships are strong then flat hierarchies are less prone to collusion and extortion and less costly to maintain than steep hierarchies. In the opposite 'cooperative' organizational cultures, when peer relationships are strong then steep hierarchies are less prone to collusion and extortion, but flat hierarchies are less costly to maintain. The case of maritime customs has greater complexity in the process; this, and the assumptions of Duggar and Duggar's context—such as costlessness of judging the veracity of an application, and independent, uniform actor behaviour—suggest that their mathematical econometric analysis will be less effective than a simulation-based analysis.

Situngkir [51] is interested in the link between corrupt behaviours in individual agents and the societal/cultural environment in which they interact. He builds a MABS inspired by corrupt bureaucrats in Indonesia and obtains system-wide results. However, these results require validation of the assumptions made.

Deviations from customs processes may be seen as governed by structural and normative aspects of the society. Savarimuthu et al. [48] examine how an agent may infer the norms of a society without the norm being explicitly given. Looking more generally at MABS, Norling et al. [43] seek to add more 'human-like' decision making strategies, drawing on studies in naturalistic decision making. Dignum et al. [14] emphasize models that include culture, to capture societal aspects such as social norms; these are relevant to studying corruption. Jonker and colleagues study (agent-based) negotiation support systems [31,44] and negotiation and culture in process-centred socio-technical systems [30,28]. Gal et al. [19] demonstrate empirically that people in the US and Lebanon behave differently in negotiation with automated agents in a repeated game; they attribute the differences to cultural factors such as collectivism.

5 Conclusion

This paper reported a work-in-progress case study of simulating social complexity in the domain of maritime customs. In this domain, understanding which reform policies are effective against non-standard practices is challenging. We gave evidence to the applicability of a methodological approach that includes evaluation and selection of modelling paradigm, and to the applicability of agent-based simulation. We reported data gathering and initial model building, to lay the foundation to understanding in a quantitative way the costs and benefits of various reform policies aimed at customs processes.

We concur with earlier authors on the value of MABS in public policy, agreeing with Hamill [23] on the need for tools, documentation of best practice, and an outcome-based argument for agent-based modelling in policy contexts. Our exploration of ABM for the maritime customs domain lends support for the ABM methodology. We also agree with Davidsson [12] and Arroyo et al. [1] on the need for validation of MABS that simulate complex human behaviours.

Our methodological meta-approach consists of ten steps: (1) Identify the scenario/system to be simulated, and the goals of the simulation exercise; (2) Make an initial methodological choice; (3) Collect data necessary for model-building; (4) Review the model and language choices in light of the data; (5) Design and build simulation; (6) Run simulation to examine potential policy decisions; (7) Analyze and interpret the results; (8) Collect data on the fit between the selected techniques and the problem under consideration, and validate the model and results; (9) Apply the conclusions to policy issues in the scenario/system; and (10) Seek to generalize conclusions.

Having selected the technique of agent-based modelling for our domain of interest, the next step—Step 5 in our methodology—is to design and build the simulation itself. At the heart of the MABS is the actors' 'walk' through the documented processes for each shipment, the points of possible deviation, the

decisions whether to engage in (or how to respond to) non-standard practices, and the negotiation that may ensue. Further fieldwork will be required in order to calibrate modelling parameters, add fidelity to the ABM, and, importantly, to understand the space of more substantive process re-engineering options.

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