ABM for routine replication dynamics v1.1.0

OVERVIEW

This is an agent-based model to explore routine replication dynamics considering two types of network contexts – namely, (1) connections between different (geographically distributed) units (which here we called "groups") in a decentralized organization, and (2) the coupling relation between routines – i.e., a bundle of different routines involved in each group.

HOW IT WORKS

To do so, we first followed the NK and fitness landscape modelling to depict routine networks, and built up the fitness landscape of an organization. Then, we translated this into an agent-based model (ABM) to explore complex behaviors.

We treated an aggregation of individuals and artifacts – namely, the unit distributed within an organization, which we called a 'group' – as the basic autonomous agent. All the groups (i.e., agents) randomly interacted with each other, while by using templates specific routines were replicated from group to group. Furthermore, we also considered the impact of both internal uncertainties and external dynamics of the organizational environment routine replications. This included, for example, template-duplicating errors and innovative activities among groups, and the pace of variation of the organizational environment.

We assumed that, firstly, group agents were prone to replicate 'superior practices' from neighbors only when they felt competitive pressures – i.e., they had a significantly lower fitness value than the average of neighbors.

Next, a template was generated through explicitly codifying the knowledge embedded in the network of routines of the replicator group agent. Being templates a copy of the original series of routines, but allowing each of the element values of the vector tpl_k ($0 \leqslant k \leqslant N$) to vary with a certain probability of errors *error_p* ($0 \leqslant error\_p \leqslant 1$).

Furthermore, given that replicatee group agents were always constrained by a specific level of absorptive capacity, we assumed that they could not adopt the whole template but only a certain part. Here, we used a variable *group_AC* to represent the absorptive capacity of group agents. Its value numerically equaled the number of routines that replicatee group agents could change at a time according to the template, *group_AC* = {1, 2, 3}. Obviously, the higher the value of *group_AC*, the higher level of the group agent's absorptive capacity was.

The replicatee group agents could randomly select a number of routines (which numerically equaled the *group_AC* value), which owned different states with those from the template – if they were existed, of course. Then, the replicatee group agents changed the relating routines' states (values) according to the template, and generated a new list of routines R'.

Finally, when the new collection of routines R’ was formed, replicatee group agents checked if they could perform any innovation to match their work of routines (obviously, here, referring to the list of routines R’) and the specific context in which they were living. This was to mimic the ‘context-dependent’ characteristic of organizational routines as well as the interconnection between routines. For example, replicatee groups could revise parts of the network of routines while considering both the embeddedness of the systems of routines and certain fitness landscapes – namely, the living environment of the groups. By doing these innovation activities, replicatee group agents transformed the temporary list of routines R’ into their final network of routines R with newly updated status.

In addition, we assumed that replicatee group agents could innovate and randomly change the state of one of their routines with a given probability *innovate_p* (0 ≤ *innovate_p* ≤ 1) – when this was helpful to improve their fitness values.

HOW TO USE IT

The SETUP button creates group agents with a random set of routines. Once the simulation has been setup, you are now ready to run it, by pushing the *GO* button. *GO* starts the simulation and runs it continuously until *GO* is pushed again. Or you can push *GO-ONCE* button to run the simulation step-by-step. During a simulation initiated by *GO* or *GO-ONCE*, adjustments in sliders can affect the behavioral tendencies of the population.

A monitor shows replicating dynamics of routines between different group agents. In this model each time-step is considered one iteration of the routine replication activities.

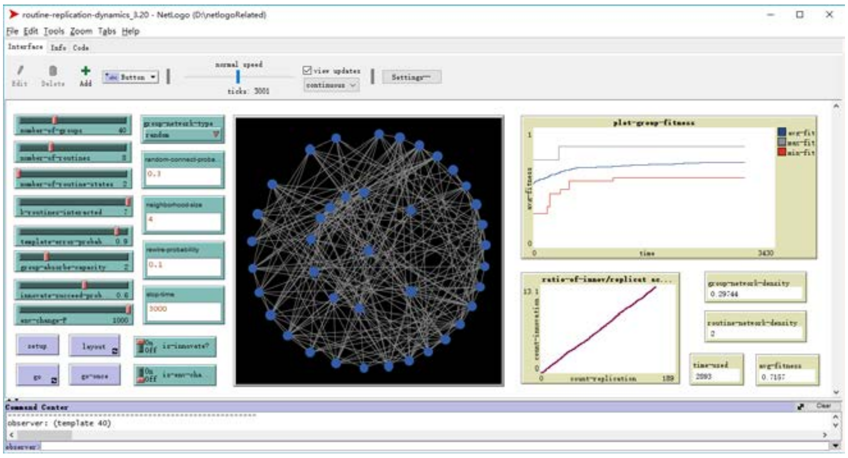

FIG.1 Interface of the model

Here is a summary of the sliders in the model:

- *num-of-groups*: The number of group agents involved in the organization;
- *num-of-routines*: The number of routines involved in each group agent;
- *num-of-routine-states*: The number of states for every routine
- *k-routine-interacted*: The number of routines that affect one certain routine’s contribution to the group’s fitness, (1 =< k-routine-related =< number-of-routines - 1);
- *template-error-probability*: The probability of errors occurring when replicatee groups

duplicated routines from a template;

- *group-absorbe-capacity*: Absorptive capacity of each group agent
- *innovate-succeed-probability*: The probability of innovative activities for each group agent;
- *env-change-P*: The simulation rounds period of environmental variations;
- *group-network-type*: In this model, we choose the E-R random model.
- *random-connect-probability*: A parameter used in the E-R random network model, representing the connecting probability between nodes;
- *neighborhood-size*: A parameter used in the SW network model;
- *rewire-probability*: A parameter used in the SW network model;
- *stop-time*: Total simulation rounds for running of the simulation each time;
- *is-innovate?*: A Boolean variable representing whether innovation activities is allowed or not;
- *is-env-change?*: A Boolean variable representing whether the environmental variations is existed or not;

Four monitors provide the outputs including density of both group and routine networks, simulation rounds used for the routine system to arrive at a stable state, and the average fitness of the organization, respectively.

The model's plots show the total number of group agents involved in both replicating and innovating activities, the average-fitness values of the organization, and the ratio of the number of group agents involved in replicating-innovative activities.

THINGS TO NOTICE

In order to reduce the impact of statistical factors involved in our model, we repeated the simulation running for hundreds of times for every different scenario according to the power analysis results, and kept each running lasting for at least 3000 rounds – here, each round representing one performance of the routine – to ensure that the organization system reached a steady status, if it eventually existed.

CREDITS AND REFERENCES

Please cite this model as the following: Dehua Gao, Flaminio Squazzoni, Xiuquan Deng (2018). The intertwining impact of intra-organizational and routine networks on routine replication dynamics: An agent-based model, Complexity, (accepted)