An Agent-Based Simulation of the Emergence of Partnership Systems in Early Renaissance Florence

Kevin T. Comer
George Mason University
Computational Social Science
Fairfax, Virginia
United States
Email:
kevin.comer.07@gmail.com

Kenneth W. Comer
George Mason University
Operations Research
Fairfax, Virginia
United States

Email: kwc5@cornell.edu

Abstract— The emergence of the partnership system in Early Renaissance Florence is often noted as a pivotal moment in the formation of capitalism. However, this social invention was not developed as a completely redefined system, but was the gradual process of adapting guild partnerships to domestic and international business. The purpose for this paper is to describe a simplistic agent-based model, where individuals form partnerships based on paradigms common in the medieval Florentine economy, as well as the results of the simulations. The final result is the emergence of entirely different partnership network structures, consistent with the structures seen in the early 15th century, as well as a rise in individual capital which led to the success of this system replicating itself across the European landscape.

I. INTRODUCTION

THE Florentine economy of the early 14th century, while diverse and dynamic by European standards, did not operate significantly differently from other places in Europe at that time. However, by the beginning of the 15th century, and decidedly by 1434, the new economic model of patronage, business alliances and international partnerships not only formed the backbone of the Florentine economy, but was being exported throughout the Italian peninsula and across Western Europe.

It is tempting to imagine these "new men of business" as revolutionaries, determined to redefine the way of doing commerce and international trade. However, this is often at odds with the relatively conservative mindset of the bankers who established this system. If anything, they were counter-revolutionaries, determined to bring order and hierarchy back to Florence after the proto-Marxist Ciompi Revolt of 1378. How, then, can we consolidate these two competing views?

A hypothesis put forth by Padgett and McLean [1] is that the partnership system, what Melis (1962) called the *sistema di aziende*, was constructed not out of whole cloth, but by adopting a formerly existing system of apprenticeship that already operated in the guilds for the purposes of business partnerships. Padgett and Powell [2] define the emergence of new organizational processes in much the same way as biological evolution, as the adaptation and proliferation of one pattern in a different context, and the improvement of that process incrementally over time.

In the context of the emergence of partnership systems, Padgett [2] in Chapter 6 defines this particular economic invention as "a set of legally autonomous companies linked through one person or through a small set of controlling partners." He argues not only that this partnership system emerged from domestic bankers adopting the partnership paradigm of the guilds, but that the impetus for this invention came in the aftermath of the Ciompi Revolt of 1378. In this turbulent aftermath, lawmakers sought to stifle the negotiating power of the tradesmen and so, unwittingly, encouraged them to form partnerships with the relatively few domestic bankers, thus propelling these men into international commerce.

A. The Ciompi Revolt and the Aftermath

In 1378, a revolt of the *ciompi*, known collectively as the *popolo minuto*, or "little people", succeeded in kicking the wealthy patricians (known as the popolani and the magnates) out of Florence for a time, in the only successful worker's revolt in pre-industrial European history. As this forced much of the wealth out of the city, export-oriented commerce ceased. This prompted the minor guilds and the liberal popolani to retake power in September 1378. This regime, in turn, was crushed by the major guild leaders and the domestic bankers in 1382.

The revolt sparked waves of political reactions, each one more elitist than the last. Each regime added layers of oversight onto guild leadership. The 1382-1393 regime, paradoxically, aimed to limit the very autonomy which granted its power by forcing approval, and eventually the selection, of guild consuls to an external body, the Mercanzia. Eventually, the oversight of guild leadership and practices had the incidental effect of encouraging guildsmen and tradesmen to produce partnerships not within the guild, but outside of it, in order to garner more capital, both political and monetary. The domestic bankers, for their part, sought to seize upon this lucrative opportunity by adopting the partnership paradigms the guilds already had in place, the master-apprentice system.

This practice proved to be lucrative for both parties, and caused the economy of Florence to flourish, most notably for the banking families. While the specific actors changed over time, the success of the partnership system – ownership of various businesses and companies – was already well established by 1434, when Cosimo de Medici returned to Florence to end up becoming the de facto ruler, with power which relied heavily on his business partners.

B. Emergence and Analysis

The goal of this paper is to model and simulate the emergence of the partnership system, through the implementation of a revolt in the simulated environment. This model will simulate agents, representing individuals, making partnership decisions. At a point in simulated time, a revolt will occur in the model (replicating the Ciompi Revolt and the aftermath), which will prompt the agents to reassert their partnership paradigm based on the laws of the new regime.

II. METHODOLOGY

A. Agents

The model designed for this analysis uses heterogeneous agents to represent stylized individuals in the Florentine economy in the 14th century. These agents do not represent actual historical figures, but rather abstracted decision makers operating on a paradigm that has been hypothesized by historians on the mindset of conservative Florentine businessmen.

The two types of agents that are represented in this model are 'bankers' and 'tradesmen'. Bankers represent the merchant bankers of Florence, who began as almost purely domestic bankers in the early 14th century and, by the beginning of the 15th century, had become international businessmen. 'Tradesmen', in the context of this model, are loosely defined as guildsmen – men who were skilled in a trade and, per the usual paradigm of the High Middle Ages, were part of a guild in the early 14th century.

Agents are defined not only by their class, {banker, tradesmen}, but also by attributes. These attributes abstractly define an individual's place in society, as well as their desirability as a partner, which will be discussed in the next section:

- Capital (c_i) – this attribute represents the relative wealth of an individual.
- Expertise (e_i) – this attribute represents the agent's skill in his craft. While there were certainly different trades in Florence at this time, this model does not distinguish between guilds at the present time.
- Age (a_i) – a simple calculation of age, which increases each year. At random points, agents will die and be replaced with a new agent.

B. Partnerships

Partnerships, either business partnerships or apprenticeships, were formed by individuals selecting a different agent that was geographically close to them as well as held a significantly high attribute in either capital or expertise. Tradesmen of the medieval period would often form apprenticeships, with a master gaining a significant amount of the capital, and the apprentice gaining experience and expertise in the craft [source here]. These master-apprentice relationships would often become enveloped into guilds, where masters of a given craft would partner together for negotiating power.

Prior to the revolt, tradesmen make decision on who to partner with in the following calculation (assuming agent j is active):

$$\min_i \left[(d_{ij})^2 - 0.1 \times e_i \right] \quad (1)$$

Where d is the Euclidean distance between tradesmen i and j. This represents tradesmen making connections to the most experienced tradesmen in their most immediate vicinity. These partnerships, like the master-apprentice partnerships they represent, are directed and non-equal.

Bankers make similar partnerships with other bankers, although the partnerships are undirected. They are formed along the following paradigm (assuming agent j is active):

$$\min_i \left[(d_{ij})^2 - 0.1 \times c_i \right] \quad (2)$$

After the revolt, the partnership paradigm of the tradesmen changes to that of the bankers - the paradigm quantified in equation (2). In addition, any new partnerships the tradesmen make will be with bankers, rather than fellow tradesmen. This aims to replicate the 1382-1393 regime and the oversight of the guilds by the Mercanzia.

These partnerships also impact the attributes of those participating. For a tradesmen that has a partnership directed out of the agent (i.e. an apprentice), his expertise (e_i) increases by one for each outgoing partnership. For both partners of any partnership, capital (c_i) increases by one for each tick.

C. Simulation Setup

This model was coded and simulated using NetLogo 5.0, an agent-based toolkit that can graphically represent not only heterogeneous agents, but also links between these agents. This model defines two breeds of agents, tradesmen and bankers, with the attributes described in section II.A. Each tradesman is initialized with $c_i \sim U(0, 10)$ and $e_i \sim U(0, 100)$, where each banker is initialized with $c_i \sim U(0, 100)$ and $e_i \sim U(0, 10)$. Both types of agent are initialized with age $\sim U(0, 1000)$, representing any age from 0 to 83 years old.

As the positioning of agents is important (both historically and in this simulation) to the creation of partnerships, the location of bankers and tradesmen needed to be defined. Tradesmen are randomly placed in the lower half of the model world, while bankers are randomly placed in the upper half of the world. The model world can be assumed to be a toroid, meaning that the edges continue along the

opposite side of the simulated world. The graphical representation of the bankers are blue person icons, while the tradesmen are red person icons. A view of the model in the middle of the run can be seen in Fig. 1.
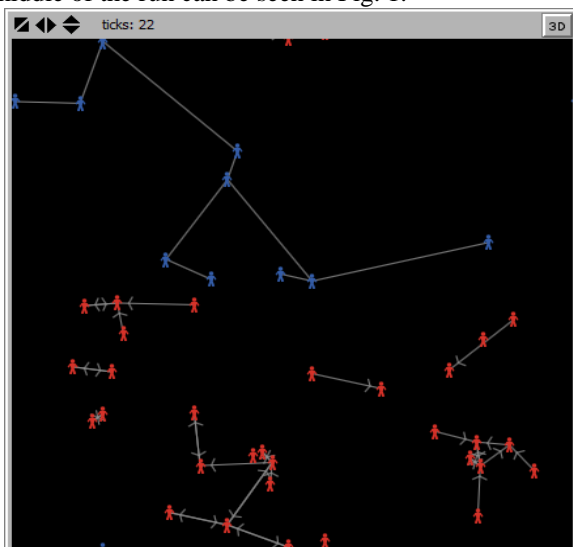

Fig. 1 Screen shot of simulation model

As time progresses from month to month, age increases by one each simulation tick. In each tick, each agent selects a random value with an exponential distribution and a mean of 600. If this is higher than their current age, then the agent dies and is replaced with a new agent with attributes holding zero values.

At a certain point in the model, the global Boolean variable "revolt", which always begins the simulation set to False, may be set to True. In the model runs described in this paper, the simulated revolt occurs in the middle of the simulation run, at t = 600. This represents the Ciompi Revolt, as well as the succeeding regimes of the following one and a half decades. Partnerships are not immediately disbanded, but a new paradigm is enacted which promotes new partnerships to form across trades, formed between bankers and tradesmen, as observed in the following section.

The model is populated with 10 banker agents and 30 tradesmen agents at time 0. The simulation is then run for 1200 ticks, where the revolt occurs at tick 600. The primary output of the model is the average per-capital capital across the entire agent population. The primary method of analysis of results was Monte Carlo Simulation, running the model for 1000 runs, with different random seeds.

III. RESULTS

A. Rise in Capital

The primary output for this model, per-capita capital across the agent population, shows a consistent increase after the revolt occurs. The null hypothesis of $H_0: \mu_0 = \mu_1$ can be tested in respect to the alternative hypothesis, $H_1: \mu_0 < \mu_1$ (one-tailed Z-test). Two averages are taken from each run - the average of the 600 observations (1 per tick) of per-capita capital prior to the revolt (revolt = FALSE), and the average

of 600 post-revolt observations (revolt = TRUE). The statistics for each of these populations across the 1000 runs is shown in Table I.

TABLE I.
STATISTICS FOR PER-CAPITA CAPITAL OUTPUT, PRE-REVOLT VS. POST-REVOLT AVERAGES

Statistic	Pre-Revolt (revolt = FALSE)	Post-Revolt (revolt = TRUE)
Average	3.3648	14.3325
Standard Deviation	0.4759	1.0231
Number of Observations	1000	1000

At any reasonable level of significance, the Z-test produces a p-value of 0, leading to the conclusion that the null hypothesis can be rejected in preference to the alternative hypothesis, meaning that the jump in per-capita capital across the model is statistically significant.

B. Network Structure

It is important to note that not only does the network structure shift across the model when the revolt occurs, but whether the networks both before and after resemble to some degree the networks that occurred in Florence in the 14th and 15th centuries.

Prior to the revolt, the tradesmen partnerships are limited in scope to 2-6 participants, usually due to the death of the master and the apprentice breaking his tie and forming new ties. Partnerships across the bankers tends to be reasonably diffuse, a banker only forming on the order of 1-3 partnerships at any given time.

This pattern changes rapidly after the revolt, when the bankers become the major hubs of networks. Qualitatively, this can be seen in the structure of the networks at the end of the simulation run, as shown in Fig. 2. Quantitatively, the number of links that bankers achieve throughout their life increases, , as seen in Table II, which displays the averages across all runs of the median and maximum degree values.
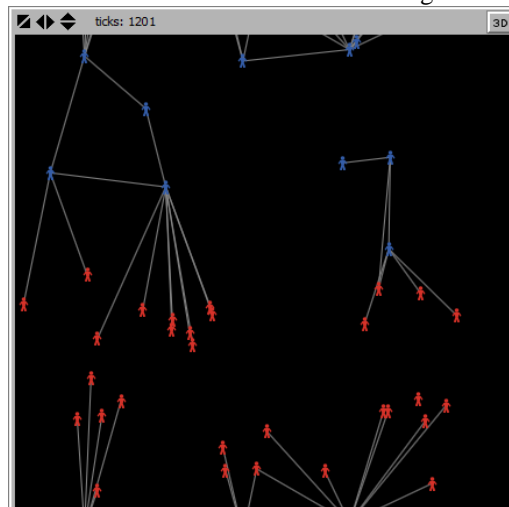

Fig. 2 Screen shot of simulation model at end of a simulation run

TABLE II.
STATISTICS FOR LINKS PER AGENT, PRE-REVOLT VS. POST-REVOLT
AVERAGES

Statistic	Tradesmen Pre-Revolt	Tradesmen Post-Revolt	Bankers Pre-Revolt	Bankers Post-Revolt
Median No. Links per run	1.9051	1.1090	1.3340	3.9971
Maximum No. Links per run	4.8188	2.7604	2.5853	10.6292

IV. DISCUSSION

A. Findings

The model was able to simulate the emergence of two substantially different networks structures across the population, punctuated by the revolt global variable. This was not generated through a top-down infrastructure design, but from agents assessing their "best" choice for a partnership. Although the selection and partnership process may not be verifiable –as certainly every banker, guildsman and contract were different – the model was able to establish some abstract, stylized guidelines that produced a new model environment.

The second interesting finding was that the per-capita capital, or the capital across the individuals, was dramatically increased, due to these new partnerships forming. Although such mental constructs as "profit margins" and "utility maximization" are not generally appropriate in the medieval or renaissance mind [3], the access to capital was of importance to tradesmen and bankers both. The new partnership system dispersed across the Western World as a mechanism for generating capital.

B. Implications

The new partnership system not only increased the wealth and influence of those partners involved, but also led to emergence of Florence as a cultural hub. This system did not emerge from a completely new creation, but the reuse of one legal mercantile construct by new actors. Bankers became the new oligarchs of the Florentine republic, culminating in the dominance of the Medici in 1434, largely due to their power derived from the partnership system.

In a more subtle extension of this new partnership system, these new republican oligarchs had ties to numerous industries, as well as the business and political acumen to survive in both worlds. These new elites were the beginning of what today we would term "Renaissance men", being the archetype of the values made possible by the partnership system, as addressed by Padgett [2].

C. Further Research

To say that this is a highly simplistic, stylized, and abstract model is accurate. There were certainly multiple dynamics going on during this turbulent time in Florentine history that led to the exact nature of the partnership system as we know it. While this model has already shown the most basic conclusion – the emergence of a partnership system from the actions of agents – more elements can certainly be added to the model to garner many more results and descriptions about this simulated Florentine Republic.

More importantly, while the qualitative structure of the partnership networks were informally validated, more thorough, formal validation techniques will be necessary to quantitatively validate this model and the results. This can be done by comparing the statistics of networks (density, centrality distributions, etc.) of the simulated networks to that of the historical networks. These data have not been available until recently; new work in this field over the past decade has allowed for analysis, and comparison, of historical networks to be analyzed quantitatively.

Finally, agent-based modeling has offered interesting and complex views into the past, illuminating on patterns of culture and society that may not otherwise be discernible through lack of archaeological evidence [4]. It is possible that this model, and others like it, incorporating agent-based models with social network analysis, may shed light on the emergence of social invention at various points in human history.

V. SUMMARY

The goal of this paper was to present a simulation model aimed at replicating the emergence of the partnership system in early Renaissance Florence. Ultimately, the structure of the network produced both prior to and after the simulated revolt within the model showed similarities to the networks documented in the late 14th and early 15th centuries in Florence. Furthermore, the rise in capital that in part derived from this new network structure was an emergent property of the model, one that may explain the success that the partnership system garnered in reproducing across Western Europe. Through this highly abstract, simplified model of network construction between stylized agents, it may be possible to answer further questions on the nature of the emergence of capitalism and mercantilism in renaissance Florence.

REFERENCES

[1] J. F. Padgett and P. D. McLean, "Organizational Invention and Elite Transformation: The Birth of Partnership Systems in Renaissance Florence," *Am. J. Sociol.*, vol. 111, no. 5, pp. 1463–1568, Mar. 2006.

[2] J. F. Padgett and W. W. Powell, *The Emergence of Organizations and Markets*. Princeton University Press, 2012.

[3] J. F. Padgett and P. D. McLean, "Economic and social exchange in Renaissance Florence," *St. Fe Inst. Tech. Rep. 02-07*, vol. 32, 2002.

[4] J. M. Epstein, *Generative Social Science: Studies in Agent-Based Computational Modeling*. Princeton University Press, 2006.