The endogenous genesis of Etruscan proto-cities:
System Dynamics as a tool for historians

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Abstract

Around the 10th century BC the rural villages in South Etruria (now Tuscany and Latium, Italy) began to disappear and a number of cities started to arise. The accepted grounds of these events deal with defense and safety reasons. Instead, our interpretation attributes the birth of the proto-cities to a sustainability crisis in the mining villages and asserts that mining technicians imposed such transition on farmers in order to carry out a sustainable reorganization of the whole system of settlements and, as a corollary, to strengthen their ruling role.
The objective of this paper is threefold: (i) To illustrate the proposed hypothesis by means of a simulation model roughly reproducing the described event, (ii) to point out the System Dynamics approach potential as an auxiliary tool in the historiographical research, (iii) to provide a further example in literature of how to model a transition phase and to handle discrete events within a continuous paradigm.
In addition to a detailed description of the model and its outputs, this paper includes an outline of historical events considered herein, some epistemological and methodological considerations, and an exposition of the next steps of this research path.

Keywords: Etruscan proto-cities, Etruscan mining and metallurgy, origin of the cities, processes of urbanization, synoecism, auxiliary sciences of history, modeling, structural change, simulation, system dynamics.

1. Introduction

The starting point of these notes is the historiographical interpretation of an event (the birth of the first Etruscan proto-cities), which in our judgement is unlikely and even contradictory.[2]

In a previous paper (Piattelli and Bianchi, 1998) we focused on the weakness of such interpretation by means of logical arguments based on quantitative data[3] and formulated our hypotheses, partly borrowed from the theories of Mumford (1961) and of Dutch archaeologist Frankfort (1951) on the origin of the cities.

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[2] See, for instance, the framework proposed by Torelli (2000).
[3] The main quantitative aspects of our arguments on the birth of Etruscan proto-cities and on their location dealt with their distance from the coast, perimeter walls, altitude above m.s.l., theoretical range of visual signals, transportation carrying capacity, sustainable population size, etc.

Now, we have developed a dynamic simulation model that roughly reproduces the considered historical event starting from the assumptions of our arguments.
The aim of this effort is three fold:

- To communicate our arguments as a formalized structure of statements (that is, in clearer and less ambiguous terms) and to involve in this research project etruscologists, archaeologists, paleoethnologists, historians, and scientists of other disciplines (including Operations Research);
- to outline the potential of the modeling and simulation approach – and of System Dynamics, in particular – in the historiographical research, and to propose it as a new auxiliary science of History;
- to provide a further exemplification in literature of how it is possible to handle discontinuities and discrete events within a continuous paradigm.[4]

The paper articulates as follows. Firstly, we discuss the methodological and epistemological aspects of application of the modeling and simulation approach (M&S hereafter) to Humanities – and to History in particular – and its hard and controversial acceptance as an auxiliary science for these disciplines.[5] Secondly, the genesis of the first Etruscan proto-cities will be historically outlined, comparing the current interpretation with our hypotheses. Then, the implemented model will be described in detail and its outputs discussed. Finally, some further historical and methodological considerations will follow and, as a conclusion, the developments needed to make this proposal a sound and effective tool for etruscologists will be advanced.

2. Modeling and Simulation as auxiliary disciplines of History

Modeling and simulation are a sort of virtual laboratory in which historians – and social scientists – may carry out their own experiments, as is the case with hard sciences. Experiments that are practically impossible to be performed in the field – and at present time. Moreover, the cost of such experiments is relatively low and they produce no sort of consequences on the real world.

The potential of System Dynamics (SD) methodology for humanities and social sciences was pointed out since its early days (Shantzis e Behrens, 1973; Low, 1981) and may be summarized as follows:

- The model building process – identifying the relationships between elements that form the event or problem under investigation – can help getting soft-scientists' ideas straight and orienting – or re-orienting – the research path;
- a formalized model can point out the consistency between premises, inference rules, and conclusions of conceptual reasoning and interpretations;[6]
- simulation runs of a formalized model provide numerical values, descripting the system under investigation for every considered time instant, that can be visualized in several user-friendly forms: A sort of filmed sequence or numerical story by which soft-scientists can compare the adequacy of their suppositions with available data and established facts;

[4] See, for instance, the guidelines proposed by Coyle (1985).
[5] Readers deeply involved in this topic, or not interested in it, may skip Chapter 2 and pass directly to the core of the paper.
[6] In our case, an interpretation of a historical event.

- the two previous points are a suitable tool to validate a historical interpretation according to the Cover Law – the so-called Popper-Hempel (Hempel, 1965, § 4);
- the above mentioned numerical experimentation – by conveniently modifying model assumptions – could make possible to carry out exploratory trials[7] for assessing other hypotheses aimed at finding new or unexpected circumstances, and *counterfactual conditionals*;[8]
- by means of the sensitivity test – a specific tool of numerical experimentation – critical model parameters could be singled out. Historians – as well as soft-scientists – would thus identify the elements to be handled with greater accuracy, orient research toward significant documents and sources, decide on archaeological excavation campaigns, saving time (and money);
- a formalized model, expressing concepts and theories straight and unambiguously, is a fertile ground in which dialogue, debate, positive confrontation and discussion may arise, rendering convergence and collaboration possible.

Of course, every scholar could take advantage of opportunities offered by such approach, according to personal needs and beliefs.

As described herein, numerical experiments can also be considered as a *thought experiment*[9] (Buzzoni, 2008) based on a technological device.[10]

For an effective and efficient use of M&S, historians and social scientists need a conceptual framework that can be found in a discipline, and the SD approach has all the features to satisfy this condition:

- Its conceptualization method, based on closed feedback loops, favors understanding and representation of the causal relationships between the numerous elements and factors that constitute the historical framework;
- several very good manuals and textbooks are available;[11]
- methodologically sound guidelines (Randers, 1980; Legasto *et al.*, 1980; Rahmandad and Sterman, 2012) – the latter especially devoted to social scientists;
- user-friendly software environments for model conceptualization and development, therefore especially suitable for soft scientists;[12]

[7] Also named postvisions or retrodictive tests.

[8] A counterfactual conditional express the typical logical statement "what…if": What would have happened if…. The hypothetical or counterfactual assumptions began to assume great importance in historiographic analysis starting with Weber (1906). It is worth pointing out that Counterfactual History – sometimes referred to as Virtual History – has little to do with Alternate (or Alternative) History, a kind of fiction literature, in which emphasis has been set on scenarios generated by the hypothetical event, whereas the interest of counterfactual history is focused on the very incident that is being negated by the counterfactual in order to evaluate its historiographical weight.

[9] The *thought experiment*, starting with Mach (1896/7) who, through his method of variation, pointed out the intrinsic connection between real and mental experiments, has its own full epistemological dignity.

[10] Besides, Popper (1957, §25) complains that social scientists must – for several reasons – rely too often on experiments carried out mentally. As matter of fact, computer M&S could help these scientists to improve their *thought experiments*.

[11] Among others: see Sterman (2000), Forrester (1968), Coyle (1996), Maani and Cavana (2007), and the *Road Maps: A Guide to Learning System Dynamics* available on-line both at MIT System Dynamics Group <http://web.mit.edu/sysdyn/road-maps/toc.html> and at the Creative Learning Exchange <http://www.clexchange.org/curriculum/roadmaps.asp>.

- a considerable number of fully documented case studies;[13]
- the website of System Dynamics Society provides all information needed, including a huge database of bibliographical references, and the paper archive of all SD conferences (ISDC);
- and, considering that the ultimate goal of every scientific discipline, including humanities, is to build theories and validate them,[14] the affinities between M&S logic formalism and the deductive apparatus of axiomatic theories could be a bridge for such delicate crossing, and – also in this aspect – SD may indicate the right directions (Hanneman 1988; Davis *et al*., 2007; Schwaninger and Grösser, 2008).

To best perform their task, historians take advantage of expertise borrowed from other disciplines, called auxiliary sciences of history. In the past century, the success of economic and quantitative history allowed statistics and econometrics to be added to the list of auxiliary disciplines[15] (Topolski, 1977).

Instead, modeling and computer simulation as well as systems approach – to both of which SD belongs – are not yet part of the so-called auxiliary sciences of history, in spite of (i) the above listed potentials, (ii) the acknowledgment of a well-distinguished historian (Voltes Bou, 1983), (iii) the editorial claim in a special issue of *Annales*, the most influential journal of quantitative history,[16] (iv) the definition of "heuristic device" by an archaeologist that usefully practiced M&S (Zubrow, 1981), (v) the epistemological acknowledgement of scientific validity achieved several decennia ago (Helmer and Rescher, 1959; Simon, 1957, 1969).[17]

In fact – contrary to archaelogists and paleoethnologists – historians have rarely taken advantage of these methodologies. Archaelogist Renfrew (1981; 1987) explains that these techniques can be of great help in giving a plausible structure to their scantily

[12] Packages defined as "core software" by SD Society are: STELLA, PowerSim, Vensim/VenPLE. Although their proper use does not require a specific training in mathematics and informatics, they are sophisticated enough to enable complex implementations and rigorous analyses. Other software packages, extending SD methodology, deal with documenting, model analysis, web-based and educational-pedagogical tools. Information can be found at SD Society portal <http://tools.systemdynamics.org/>.

[13] A non-exhaustive list of SD applications in humanities and social sciences includes sociology of science (Sterman, 1985; Sterman and Wittenberg, 1999), ethics (Pruyt and Kwakkel, 2007; Kunsch et al., 2007; Geistauts et al., 2009), anthropology (Shantzis & Behrens, 1973; Kampmann, 1991); literature (Hopkins, 1992; Joy, 1995; Haslett, 2004), philosophy of history (Torrealdea and Grana 1984), psychology (Wegman 1977), dyadic behavior (Radzicki, 1993; Kurstedt, 2003), and economics (Schuster 1973, Low 1980). Besides, numerous SD applications in close disciplines, such as management science, and seminal works such as the series of *World Dynamics*/*Limits to Growth* (Forrester, 1971; Meadows *et al*., 1972; Meadows and Meadows, 1973; Meadows *et al*., 1974; Meadows *et al*., 1992; Meadows *et al*., 2004) and the thread of *Urban Dynamics* (Forrester, 1969) can provide a heuristic contribution.

[14] Or – better – as Popper suggests, to falsificate (or to refute) theories.

[15] The so-called traditional auxiliary (or ancillary) sciences of history are: librarianship, heraldry, sphragistics, numismatics, palaeography, metrology, chronology, archival holdings, papyrology, epigraphy, etc.

[16] Lepetit (1988, p. 4), in his editorial in the special issue of *Annales* dedicated to "History and Modeling", states explicitly: «…if quantitative history recently seems to be subject to the law of diminishing returns, it depends on its downgrading to elementary descriptive statistics. …[*omissis*]… Quantitative analysis should take advantage of other richer techniques, i.e. model building and simulation that disclose deeper procedures».

[17] Besides, Popper (1957) asserts that the experimental methods of physics may be – with the necessary precautions – applied to the social sciences (pro-naturalistic discipline).

available material[18] – that is, in their task of devising hypotheses. Therefore, M&S historical applications have mainly dealt with prehistory and early civilizations.[19]

Incidentally, the model presented herein also falls within this category.

There are several reasons why historians that deal with source-rich ages do not take advantage of proposed methodologies. A deep treatment of these motivations goes beyond the extent of this contribution. A simplistic interpretation could be that they do not feel the need of it since they consider the mass of available data and its statistical elaboration sufficient to formulate their interpretations. However, a suspicion may arise: Do historians and social scientists still suffer the late nineteenth-century dichotomy between "spiritual" and "natural" sciences pointed out by Dilthey (2002), or the dualism between nomothetic and idiographic sciences[20] introduced by Windelband (1947, pp. 160-167), and the bridge between the two cultures (Snow, 1959) has not yet been completed?

This contribution, obviously non-resolutive, can offer a basis of discussion for reviving the debate on the adoption of formalized approaches for the historiographical research, and on the origins of the first Etruscan proto-cities.

3. Genesis of the first Etruscan proto-cities: The historical framework

3.1 *From initial conditions to crisis*

Around the 10th century BC, the flow of people through the Mediterranean, due to the latest invasions by Indo-European populations, is over. Stability again promotes trade and the demand for metals. In Italy, between the rivers Tiber and Arno, live metallurgical engineer-technicians who came here early and became permanent residents thanks to the abundance of mining resources: The greatest ground concentration of metals in Central Mediterranean. They are not Indo-European, nevertheless their archaic civilisation is strong enough to permit their survival and development.

During the so-called Villanovan period, such a territory is scarcely populated: Villages are located where resources are plentiful and easily exploitable. Differences occur in the prevailing activities and related environment. Mining districts are woody and hilly, unsuitable to large farming (Elba Island, before deforestation due to metallurgy, is an appropriate example). To manage their activities, metallurgical technicians live in the mining villages. Rural villages arise in fertile areas, such as the coastal plains and alluvial valleys. Their inhabitants are more numerous, but "culturally" less developed.

Populations in the two areas show different expertise and activities, but also common aspects due to their close proximity and some limited synergistic relationships. At least, connections occur to exchange surplus: Tools from one side and foodstuff from the other.

[18] Also for these particular conditions of data deficiency, the SD approach showed its effectiveness (Schroeder, 1972).

[19] See, for instance, Low (1981) on Anasazi disappearance from Colorado Plateau and Hosler *et al.* (1977) on the Maya collapse. Besides, it is worth noting this bias exists not only for SD, but also for other M&S methodologies: Historical applications of the Agent Based approach mainly belong to prehistory and early civilizations (see, for instance, Kohler and Varien (2012); Cordell and Gumerman (2006); Christiansen and Altaweel (2006); Doran (1994/5)).

[20] In modern terminology, hard and soft science.

These operations produce material effects, such as roads and ships, and cultural effects, such as attractiveness towards the more developed area.

The mining and "industrial" district increases production for the foreign market, also in view of the poor and marginal internal market. Contacts with foreign countries have ancient origins, but the new Mediterranean stability increases metal demand against luxury articles. Such a trade favours cultural exchanges, that promote civilisation, and political unity in the mining districts.

Production, considered at a constant technology, increases if labour increases, but population growth creates serious problems due to limited local food resources. On the other hand, low productivity of farming villages, based on a survival economy, cannot compensate for the food deficit of mining villages. In any case, transportation of great amounts of foodstuff would not be convenient.[21]

This raises the need for a new organization of the territory as a city-state, and the city is founded. The mining area dominant group assumes the domain of rural villages, incorporates them into the city,[22] moves in with servants and part of industry workers, relocating workshops inside the urban structure. This move satisfies two fundamental objectives of the dominant group: Acquisition of food resources and recruitment of labor. There are, however, other complementary objectives that, in some cases, may be associated with the fundamental ones:

- In the case of Elba-Fufluna, depletion of the island forests forces to carry the iron ore to the coast, a less hard solution than carrying charcoal to the island;
- the direct control of transport routes and sites for trading abroad.

However, such complementary goals deal with *where* to erect the town, rather than *why*.[23]

The choice of the site for the city foundation will respond to a specific requirement: The location of the settlement must be barycentric with respect to resources and territory control.

A new organization is needed and will be imposed by culture and weapons.[24] Etruscan culture shows a *discipline* model[25] capable of producing a high quality of life, including material wealth. This is attractive enough for people less evolved.

In conclusion, the culture toolkit can be reduced to the ability to produce wealth and how to deploy and use it: An overall rewarding ability. This attractiveness[26] favors the recruitment of labor force (indispensable for the foundation of the city) and the subsequent dominion over it. As to weapons, the warriors' power deriving from metallurgy looks impressive, despite their small number. The legend of royal Rome and the Mastarna cycle shed light on the procedure: An armed group takes position in the future acropolis, and succeeds in imposing its own king to the surrounding villages.

[21] Let us make the following optimistic assumptions: (i) a road suitable for 220 Kg load carts, pulled by four mules, (ii) six days the length of the round-trip, (iii) carter and mules procure half of their food on the way, and consume half of the cart load. The remaining half they deliver feeds one person for 110 days. To nourish 500 persons for a year, with only six transport-favourable months, would take at least 65 carts and 260 mules.

[22] Part of the rural villages are incorporated within the urban perimeter, whereas the remaining ones in the surrounding fertile territory are leveled to the ground.

[23] In fact, Fufluna (today's Populonia) is the unique example of Etruscan coastal city.

[24] This behavior would confirm Plato's assertion in his *Republic* (380 BC) that oligarchy is imposed by a *coup d'état* or prepared by means of intimidation or terrorism.

[25] Ancient Romans called it *tusca disciplina*.

[26] Etruscan social stratification has not yet been well explained – but, for this purpose – the censure of ancient Greek historians on some benefits of domestic attendants, such as luxury clothes and ownership of private residences, could be enlightening.

It is worth remembering that both the instruments of domination – wealth and weapons – are provided through metallurgical skills. And the remote culture, that permitted the development of these skills, also included the concept of town.

3.2 *From foundation to a new development*

The foundation of the city is a rite which implies some political effects: Acceptance of the rule of technician oligarchy by farming village people, and residence within an urban perimeter.[27] It is a perimeter ideally marked by the plough, but real in its sacredness[28], physically erected on high ground with cyclopean walls that conclude the event, as a confirmation of farmers' acceptance.

Technicians become the princes of the city-state; there they transfer their relatives, their slaves and workers of activities that can be accomplished far from mines. As magistrates, they monopolize the means of social control.

Such transfer meets at least two needs: (i) To exert a direct control on the new dwellers and their activities and (ii) to move people closer to food resources that have to be increased.

The birth of the city-state increases farmers' development by giving them competence and tools.

The resulting boost of food produce per capita gives rise to:

- Abundance of food beyond own sustenance needs, the surplus becoming a source of further enrichment;
- excess of labor force that may be employed in industrial activities and, as a way of social stabilization, in great civil works: Hydraulic soil control, which play a key role in the sustainability process,[29] and also cyclopean walls, roads, bridges, ships, luxury tombs, etc.

Civil works contribute to strengthen the rule of technician-princes, both at functional level and as power symbols.

Assuming a constant technology, production increases with the increase of labor. Nevertheless, the exchange value of produce grows with welfare: Artworks against raw ingots, wine and olive-oil against corn. By the same process, consumption value grows. The growth of consumption and exchange value of goods and foodstuff made the development of the Etruscan village system possible, which became self sustainable thanks to the reorganization that had begun with the city foundation.[30]

In conclusion, the city foundation is the tool that made Etruscan village system sustainable.

Figure 1 shows a map of the main Etruscan cities and the extent of Etruscan civilization and Table 1 provides a decoding key of the early names of the Etruscan cities mentioned in this paper.

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[27] Calculations indicate that farmers-dwellers may exploit agricultural soil around the city within a range of six kilometres (see Piattelli and Bianchi, 1998).

[28] *Pomerium* for ancient Romans. See, for instance, the legend of Remus death at the hands of Romulus during the foundation of Rome.

[29] Hydraulic control of soil assumes a key role in the process of sustainability of Etruscan system. It allows to extend the fertile soil and to increase food yield per acre. The causal loop diagram in Fig. 6 illustrates how it enables development and works as a stabilizing element for the overall system.

[30] The key elements of this process are (i) hydraulic soil control to increase food productivity, avoiding danger of social instabilities due to food shortage, at the same time making possible to shift farmers in excess to other activities, and (ii) power centralization that enables an effective control on population, optimizing allocation in productive activities and regulating migratory flows.

Fig. 1 –Map of the main Etruscan cities[31]

3.3 *Historiographical remarks*

The authors' explanation of events in the previous section differs from the current one with regard to the role of the city, which is born not to keep enemies out, but to keep rural population within. In other words, current historiography ascribes the inclusion of rural villages inside the walls (namely Etruscan synoecism)[32] to reasons of military defense and protection against threats stemming from climate and weather, hygienic conditions, animals and the unknown.

[31] Credits: The map has been taken from the Wikimedia Commons repository and released under the terms of the GNU Free Documentation License. Author: Norman Einstein.
Link: <http://en.wikipedia.org/wiki/File:Etruscan_civilization_map.png>. Last access: August 15, 2013.

[32] Synoecism, from the ancient Greek *synoiksmos*, etymologically means "dwelling together in the same house".

Moreover, such interpretation provides no clear position on the nature of the event (imposed, shared, agreed or forced by whom?), nor does it take into reasonable account the mining activities, the presumable sustainability crisis induced by food shortage and lack of regulation of migratory and transfer flows which, in our opinion, gave rise to the need of reorganization.

Our interpretation is partly borrowed from some suggestions of Mumford (1961) e of Dutch archaeologist Frankfort (1951) on the origin of cities, concerning the inclusive role of the walls and a ruling class forcing the event. In our case, however, it is the engineer-technician who became king, not the hunter.

This analysis matches archaeological evidence, such as the presence of several former villages within the urban perimeter, and the cultural continuity of burials which declined when a higher level of wealth produced monumental tombs.

Etruscan	**Latin**	**Italian**
Chaire, Chaisrie, Caisra, Kisra	Caere, (greek)Agylla	Cerveteri (and its *frazione* Ceri)
Pupluna, Fufluna, Pupuluna	Populōnia	Populonia
Rasela, Rusle	Rusellae	Roselle, Grosseto
Tarchuna, Tarchna	Tarquinii	Tarquinia, Corneto
Veia, Veina, Veis	Veii	Veio
Vatluna, Vetluna, Vetaluna, Vatalu	Vetulōnia	Vetulonia
Velathri, Velathera	Volaterrae	Volterra
Velch, Velcal, Velcl	Vulci	Vulci or Volci

Table 1 – Decoding table of the names of the mentioned Etruscan cities[33]

A further aspect of our interpretation would explain the chronic shortage of princes in comparison with the abundance of resources. The reasons are neither ethnic nor demographic, but functional and cultural: All managerial roles were assumed by a few families that sole had the necessary knowledge (*tusca disciplina*) and condition to pass it on.

For a more detailed discussion of our interpretation, reference may be made to our previous contribution (Piattelli and Bianchi, 1998), which includes quantitative data on eight Etruscan proto-cities:[34] It highlights the weakness of current interpretation of the birth and location of cities, mainly based on defensive and protective reasons.

4. The model

4.1 *Why a model*

We anticipated in previous sections that our interpretation of the birth of Etruscan proto-cities is based on logical argumentations and quantitative data (Piattelli and Bianchi, 1998). Why now build a dynamic simulation model?

[33] Credits: The table content is an excerpt from the table in Wikipedia page of “Etruscan cities”. Link: <http://en.wikipedia.org/wiki/Etruscan_cities>. Last access: August 15, 2013.

[34] Our arguments mainly relate to data concerning elevation above sea level of eight cities (Caere, Populonia, Roselle, Tarquinia, Veii, Vetulonia, Volterra and Vulci), distance from the sea, perimeter of the walls, theoretical range of light signals based on gradient, flow of peasants, soldiers and goods on foot and on horse, sustainable population size, etc.

The reasons are more than one.

The main purpose is to communicate our interpretation of Etruscan synoecism by means of a formal model that reproduces the ascertained historical path. In the terms used by methodologists for the Cover Law (Hempel, 1965), resorting to a formal model means to make explicit premises (causes, contributory causes, boundary conditions) and inference rules that automatically generate conclusions, leaving no lexical ambiguity.

The model may then become a base of discussion among scholars (historians, archaeologists, experts in other methodologies):

A step ahead to test the model potential as a virtual laboratory for historiographical research, aiming at promoting M&S – SD in particular – as a new auxiliary science of history.

Finally, modeling a singular event such as the genesis of a city is not commonplace: The evolutionary discontinuity involved requires structural changes within the model.
The authors accepted the challenge and now advance it as a further example of handling discrete events through the SD approach.[35]

4.2 *Methodological remarks*

The city birth is interpreted herein as a discontinuity in the social system behavior. An unsustainable growth causes a crisis in the Etruscan village system. The city achieves an organizational change that restores sustainability.

The simulation model structure is invariant and includes an *a priori* formalization of three transients: Before the crisis, transition (city birth), after the foundation. It is implemented as a continuous-time system, but the transition is a discrete event. Such transition implies the emergence of new – previously "sleeping" – relationships, and the modification of a few significant parameters.

The city birth is handled as a discrete event within a continuous simulation technique. This key event may assume different names according to the chosen methodological reference paradigm: Singularity (Bruter, 1989), discontinuity, point of bifurcation, emergence, self-organization.

Model time horizon ranges from the remote conditions of an apparently stable evolution to the stability of the new organization, passing through the sustainability crisis and the transition.

The pattern of the dynamic simulation model may be summarized in the sketch of Fig. 2.

[35] Obviously, they are also aware that today's software packages make this task easier.

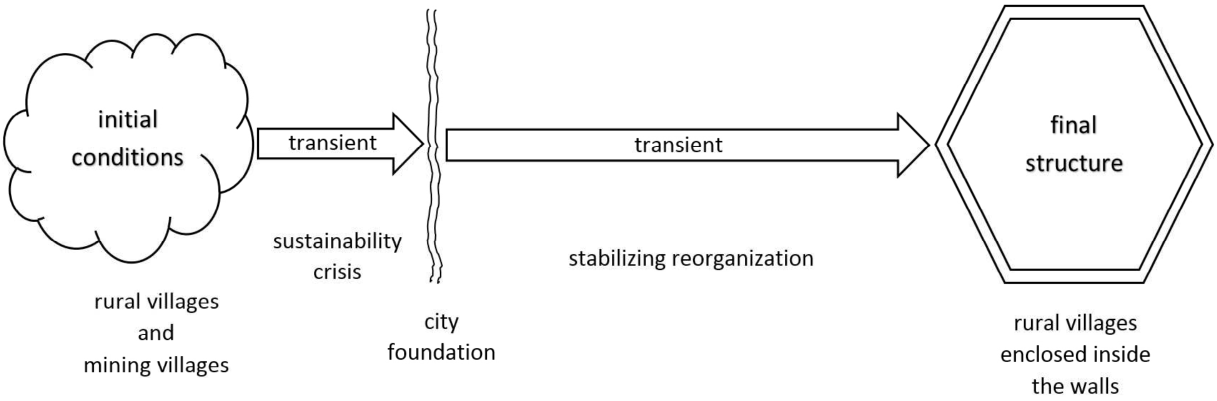

Fig. 2 – Pattern of the dynamic simulation model.

Since the new organization has been determined *a priori*, in our modeling process transition is deterministic, whereas its starting time is casual, depending on some random disturbances and on the value of initial condition and parameters.

The difficulty of handling a transition within a model has been theorized and defined by Domingo and Tonella (2000) as a structural change. Our approach essentially follows the heuristics suggested by Richmond (1981): Compatibility is obtained incorporating *a priori* within the model structure the necessary substructures for the three phases of the transition (before, during, after). Transition activation depends on particular value intervals assumed by some key variables.

To explain and/or reproduce a certain kind of behavior, each of the three phases of the model may be represented at a different conceptual distance.[36]

The time base of the simulation has been set to one year and the integration step (DT) to one quarter of a year – i.e., a seasonal pace. The model has been implemented in COSMIC-COSMOS (Coyle, 1994, 1996), a simulation and optimization environment based on a DYNAMO-like coding formalism (Pugh 1983; Pugh and Richardson, 1981).[37]

4.3 *Generalities*

Initially, the territory of the modeled system includes two areas (mining-industrial and rural) in which the population is distributed.
In our modeling purpose, five social groups or actors are considered:

- Technicians (the future princes)
- domestic attendants, men-servants or slaves
- industrial workers (miners, ironmen and craftsmen)
- food production workers in the industrial district (farmers, peasants)
- population of the rural district

Technicians and slaves poorly contribute to productive activities with limited foodstuff from hunting, fishing and vegetable gardens. Domestic attendants, men-servants and

[36] Conceptual distance (Forrester, 1961, p. 96; Richardson, 1991, pp. 157, 271, 336, 342) is the distance from which we see the world during the modeling process: practically, a synonymous of model resolution or aggregation level.
[37] The model porting to a common SD language is under way.

slaves are a consumer group, subject to its own dynamics as to their transfer from the rural pole and to purchases abroad.

The industrial pole has unlimited mineral resources and limited fertile soil for food production. The rural pole has no mineral resources, while its agricultural potential is virtually unlimited.

The industrial pole produces, exchanges and accumulates wealth. It is an open subsystem that receives mining resources from the *sources* and exchanges the relevant products with the *sinks*.[38] Per capita production and consumption increase with wealth.
The rural pole has a subsistence economy that does not allow the accumulation of wealth. Its production guarantees a minimum reserve and, in the best years, a modest surplus to exchange with the other pole.

Economic variables are food reserve levels for both poles, and the level of industrial wealth for the mining pole only.
The same net demographic rate (1.1%) applies to both poles, since the higher mortality in the activities of the industrial pole is compensated by the lower natality of the rural pole to balance the available food resources. The city foundation represents a guarantee for the future and determines an increase of birth rate (+0.1%) in all social groups.

Territorial uniformity permits the application to each pole of identical values for random disturbances on agricultural production (within 20%) and birth rate (within 0.2%).

4.4 *Initial conditions*

The initial conditions of the model reflect what has been described in Chapter 3.1. There are two separate areas: The mining and industrial district with a limited and rather fertile soil in the surroundings, and a fertile region hosting several rural villages. The two poles have modest interaction and a limited exchange of goods, whereas the industrial district exports its mineral and metallurgical production satisfying the increasing demand.

The initial values of level variables and parameters have been conveniently set so that the conditions which determined the city birth may be reached, and the instant of its occurring becomes acceptable. Values chosen for the simulation run, shown in the next chapter, are referred to a relatively remote condition satisfying previous descriptive analysis.

Demographic balance set for the model also considers an emigration flow of princes and slaves, slave acquisition from foreign countries, and a transfer of rural population to the role of domestic attendants in the princes’ residence.

Per capita production and consumption are constant in the rural pole. The incidental surplus contributes a 20% to food reserve stocks, while the rest is exchanged with the industrial pole.

The wealth accumulated in the industrial pole consists of non-food production – conveniently reduced by 10% for internal consumption, and by the exchange balance for acquisition of slaves from abroad, and food purchasing from rural villages – added to food reserve stocks. Per capita production and consumption are indexed by the per capita accumulated wealth, averaged with a two-year `SMOOTH`.[39]

[38] Sources and sinks (or wells) – typical metaphors of SD approach – represent the external environment, i.e. everything that is not included in the modeling process.
[39] A two years time constant represents the segments of a socio-economic feedback: The measure/perception of a phenomenon in the first year, the decision/action in the next one.

The Etruscan two pole behavior depicted herein deals with a system tendentially subject to an unsustainable growth and is represented in the causal loop diagram (CLD) of Figure 3.[40] This representation focuses on the relationships between the whole Etruscan system and the external environment, rather than on interactions between the two poles, considered less significant from a sustainability point of view.

The diagram clearly reveals a system (farming villages plus mining villages) fundamentally subject to exponential growth. Interaction with the external environment, such as trading and migratory flows, could potentially be a balancing factor, but also cause a reinforcing effect depending on their polarity, direction and typology. Obviously, food crisis and manpower problems (deficit or surplus) in the industrial pole are counterbalancing factors, but they are undesired conditions to be counteracted.

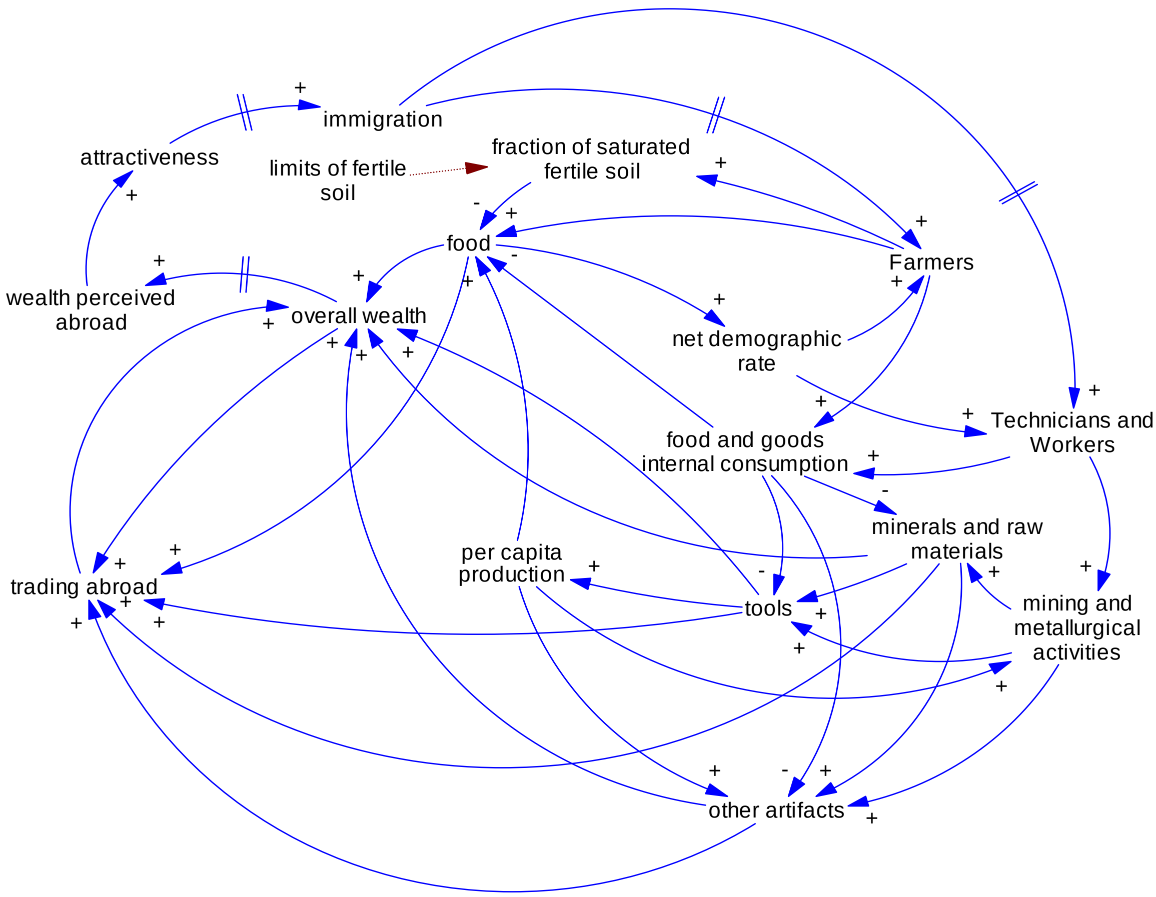

Fig. 3 – Causal loop diagram of the initial conditions of Etruscan village system (simplified view).

[40] Reasons of visual intelligibility suggested a high level of aggregation of some variables, such as “overall wealth” and “trading abroad”, and their relationships; some further explanation may therefore be of help. Wealth surplus – summation of all produce minus internal consumption – allows for trading with the external environment. Since at this level of graphical representation it is impossible to specify all input and output combination of these relationships, it is assumed that export goods value/quantity equalize import, feedback arcs to the respective system variables are not included, and only a general feedback on “overall wealth” from trading is given. Money payments are also implicitly included in the postulated equalization, as well as slaves, considered as exchange goods in those days. Since their number was hardly significant, no links to population variables are specified.

4.5 *Transient preceding the city birth: The crisis in the mining district*

During the initial slow-grow period, the influence of interaction with the external environment is rather insignificant and proves insufficient to compensate when the crisis hits. In fact, trading at the time did not allow for consistent food restocking, on account of foodstuff perishability and slow, limited transportation.

Moreover, a regulation of migratory flows, that could act as a balancing factor in a food and production crisis,[41] appears almost impossible without a centralized control.

CLD of Fig. 3 shows *how* and *why* the crisis occurs. The *when* depends on exogenous demand for minerals and goods, on the perception of wealth which attracts immigration, and on random disturbances taken into account in the simulation model.

The first sign of the crisis appears in the mining district. There, productive fertile soil is limited and, when it becomes saturated, farmers in excess begin to transfer to mines and workshops, becoming miners and industrial workers.[42] This process is illustrated in the CLD of Figure 4.

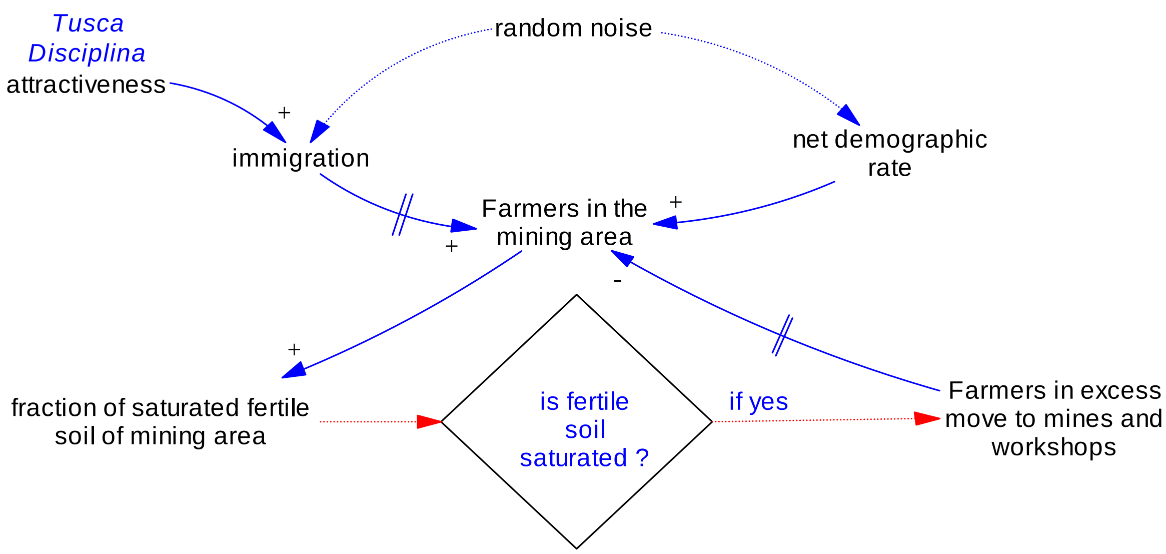

Fig. 4 – Causal loop diagram of the first sign of sustainability crisis (simplified view).

More workers in the mining district mean an increase in industrial production, but at the same time food consumption increases, and food shortage destabilizes the system. Exchanges with the rural pole, higher food productivity with respect to consumption, and the quantity of foodstuff reserve stocks delay the crisis. Random disturbances (higher

[41] Potential manpower deficit could not be overcome by buying slaves abroad: Acquisition was often impossible (slave availability presented wide fluctuations) and unreadily productive slaves would only contribute to population growth, worsening the food balance.

[42] Model implementation sets the condition of saturation as true when soil exploitation exceeds 64%, in this case transfer of farmers to the industrial pole starts with a seven-year time constant. Technically speaking, in a answer to a step of value *z*, such percentage of *z* is the value returned by a first-order delay (i.e., a SMOOTH) of any length. In our case, it means an anticipatory perception of the event.
The seven-year time constant represents a typical cycle in a rural society, and corresponds to the time interval of the slash-and-burn practice.

natality seasons and/or poor harvests) determine the precise instant when the crisis begins.

Crisis starts when the food available in the industrial pole is lower than 90% of the demand.[43] A seven-year `SMOOTH` on food balance alert threshold determines the time between the beginning of the crisis and the birth of the city, during which food reserve stocks balance the deficit. Such a time interval is assumed as long enough for decision making: Choice of the city location and preparations for the foundation.

A graphical representation of the crisis conditions for the determining the city foundation is shown in the CLD of Figure 5.

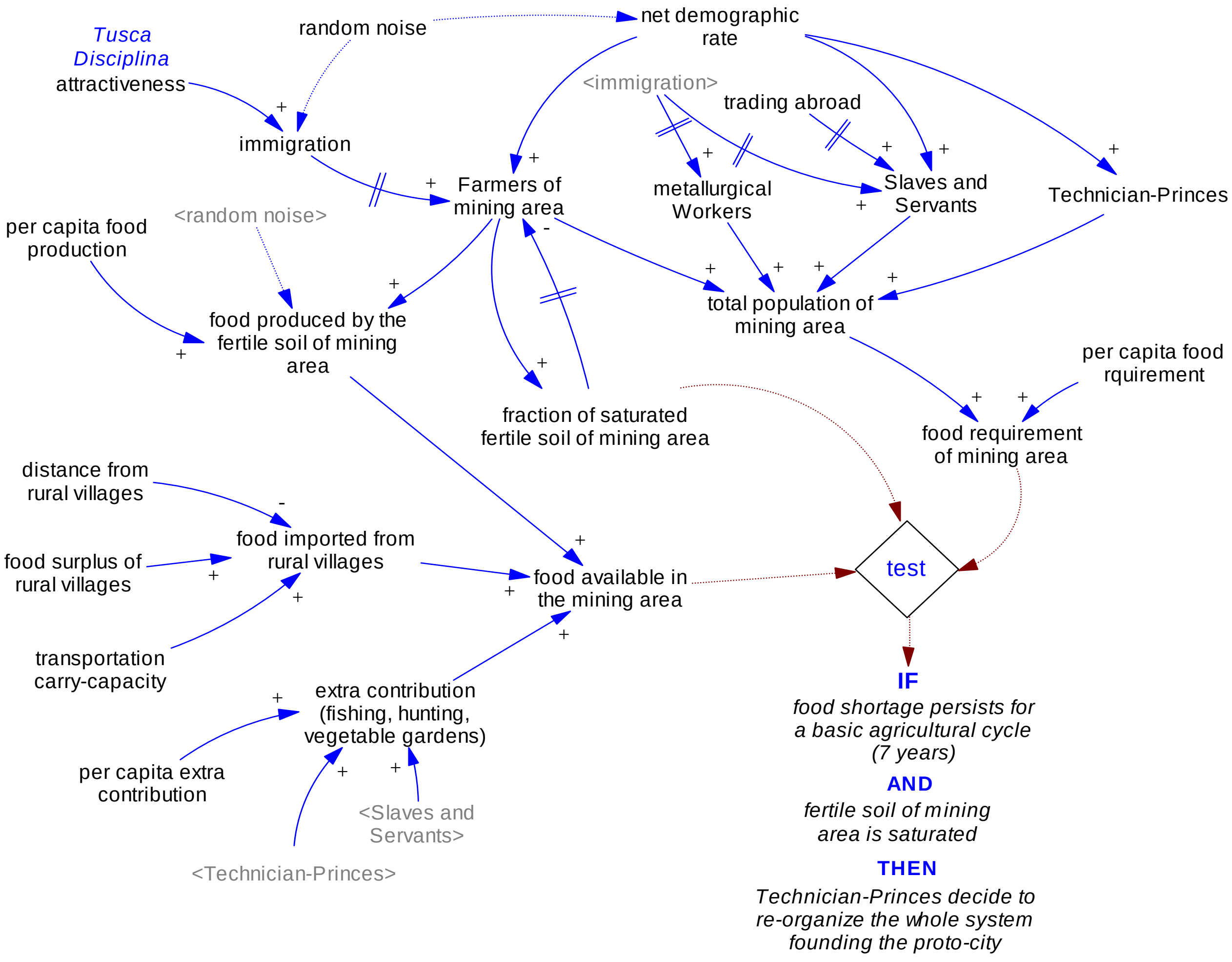

Fig. 5 – Causal loop diagram representing crisis manifestation in the mining district (simplified view).

4.6 *City foundation*

Once the time delay between crisis perception and the symbolic act of marking the urban perimeter has elapsed, the transfer of part of population and activities within the founded city begins.

[43] Per capita caloric needs have been set in analogy with the bread ration of a Roman legionary.

At this point of the simulation, the switch-variable of the city birth indicator changes its value from zero to one and, as coefficient, activates several relationships and parameters – previously “sleeping” – of the new urban structure.
Transition details will be illustrated in the next paragraph.

4.7 *Transient following the birth of the city*

As specified above, the city is founded when the switch-variable of the city birth indicator changes from zero to one.

The newborn urban population includes former rural village people and princes with their attendants, and half the workers of the industrial pole who move into the city with their activities, smoothed over a seven-year time constant. Therefore, a further variable featuring urban population has been added on account of the transfer of all farmers from rural villages and part of industrial pole people inside the urban perimeter.

This event also corresponds to a step in wealth per capita, since industrial pole wealth is now redistributed over the whole population. Furthermore, rural population per capita production and consumption, which were previously constant, depend now on wealth, smoothed over a 21-year generational time constant.

The after city foundation transient includes different time lengths for population, economic aspects and industrial activities.

Wealth per capita shows a step downwards as the average wealth of the industrial pole is now distributed among the entire population. This effect is softened by the food surplus of the former rural pole, which contributes to the total wealth. Thus the resulting transient for produce and consumption, indexed on wealth per capita, becomes rather long. Economic values of the former industrial pole population quickly rise again, whereas former rural pole values adjust over a twenty-one-year generational time constant.

These effects and some minor adjustments in the model variables relationships are activated or deactivated by the zero-one switch-variable that plays the role of a coefficient, while other variables such as *average wealth* and *food produce per capita* and *farmers consumption*, are modified by logical instructions like `IF_THEN_ELSE`.

The transient after city foundation is considered completed when mining village residents start to grow again.

4.8 *Final conditions*

When the transient after the city foundation ends, all transfer into the city have been concluded, and great civil works are under way, and some are finished.

Transfer of part of the people from mining district into the city near the food resources allowed to solve the crisis caused by food shortage in the mining areas. But the advantage of the city birth is not limited to this particular. Such event makes possible to stabilize the whole system of the two Etruscan areas, and a sustainable development phase can start: Industrial production grows more quickly than food production; food production grows more quickly than food consumption, while population growth is potentially under control.

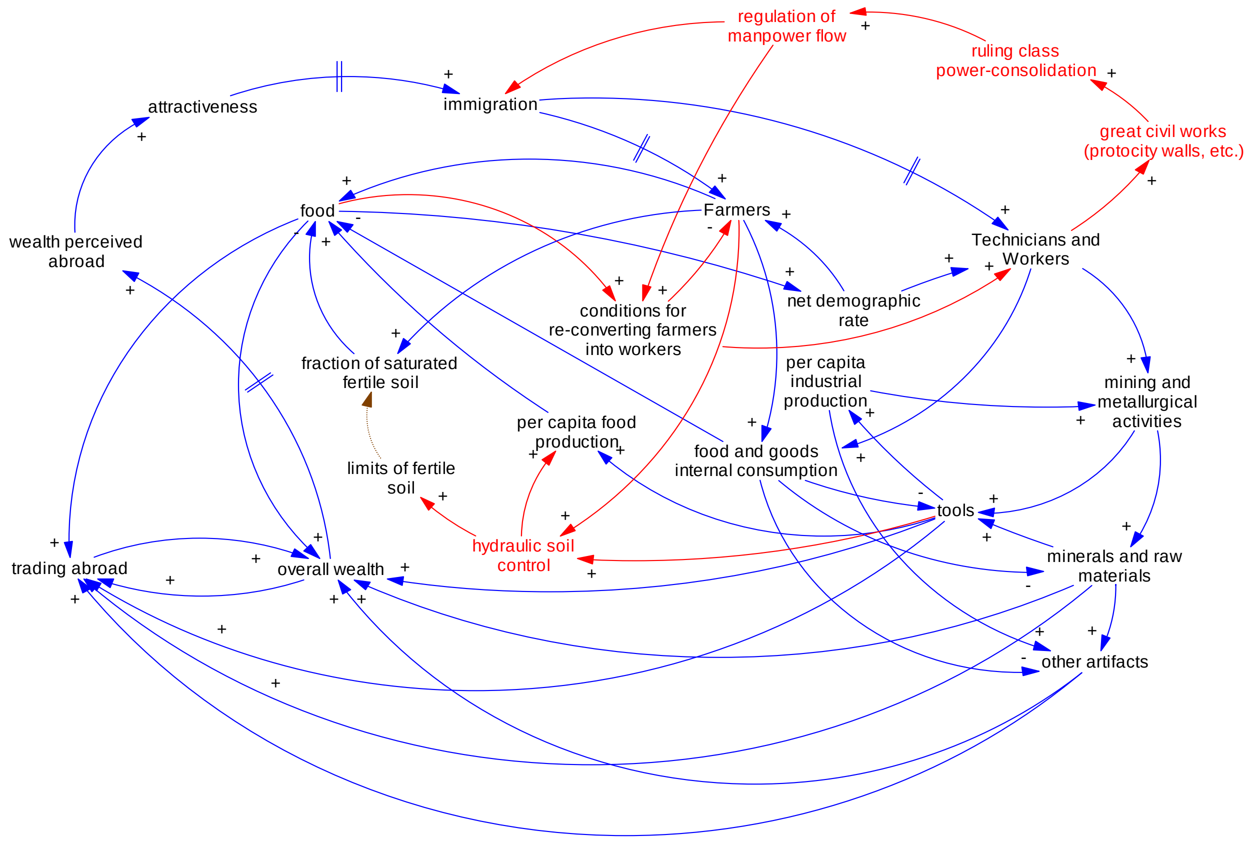

Fig. 6 – Causal loop diagram of the final conditions of Etruscan village system (simplified view).

CLD in Figure 6 shows the stabilizing effect of the city birth on the sustainability crisis in the entire complex of Etruscan villages.[44] In this graphical representation, new elements – marked in red – compensate the exponential growth that generates a social and productive crisis. Centralization of power in the city gives the ruling class of technicians better control on the population: Optimized allocation of manpower based on needs and requirements, and regulation of migratory flows – also by means of the walls to be erected.

Transfer of workers from the industrial district not only solves the food shortage in that area, but also, as already said, makes the sustainable development possible. In fact, these workers will perform work for the hydraulic control of soil and make metallurgical tools available. This will extend the fertile land and give a better yield per acre, avoid future food crisis and increase farmers food produce per capita – a factor that allows to move part of the farmers to other productive activities (mines or workshops).

Besides, technician-princes will usefully employ the manpower in excess to perform major civil works – cyclopean walls, roads, bridges, public buildings, ships, luxury tombs, etc. – of high symbolic value, that contribute to strengthen their power.

[44] It must be noted that the polarity of relationship between “regulation of manpower flow” and “immigration” may assume either sign (favouring or preventing the migratory flow) and has not been specified in CLD of Fig. 6.

It may thus be said that the birth of the city has been the tool that gave the Etruscan civilization stability, wealth and prosperity for a long time.

4.9 *Simulation runs output*

The plots shown represent the most significant results obtained from several simulations runs for model calibration and validation. The chosen initial values and characterization parameters make the model qualitatively fit for the behavior of a remote framework.[45]

The simulation time horizon is set to 200 years and the city birth event appears conspicuously on plotted outputs. The event occurs at the 83.5th simulated year.

The first transient begins at year 71 – when soil saturation in the mining district is perceived and farmers in excess begin to move towards mines and workshops – and lasts 12.5 years until city is founded; it includes a segment that begins at year 76 – when the food shortage is perceived – and lasts 7.5 years.

The second transient begins when the city is founded and ends at year 151.5, when population in the mining district commences to grow again compared to the values prior to the city foundation. Therefore, it lasts 68 years. This second transient includes a segment starting at city birth and ending at year 101.5 – when the derivative of the population in the mining district becomes positive[46] – lasting 18 years. In the period of time during this segment, almost all transfers within the urban perimeter are to be considered concluded, whereas the second transient also includes the commencement of all great civil works and the conclusion of part of them.
All transient time specifications are easily identifiable in the plot diagrams.

Figure 7 shows population dynamics. The higher growth rate of urban population (and consequently of its totals) is due to slaves acquisition abroad and to attractiveness for immigrants.

Figure 8 clarifies transfer dynamics from the industrial pole to the city and from farming to industrial activities, showing the behavior of three indices expressed by the following ratios:

- City princes / total princes;
- industrial city workers / total industrial workers and miners;
- mining pole farmers / theoretical maximum number of farmers on the mining pole soil (i.e., fertile soil saturation limit).

Transfer of farmers in excess to industrial activities becomes an opportunity to increase industrial production. Such growth is possible – and sustainable – with the support of technological innovation provided by city birth event: Availability of skilled workers, workshops producing tools, and hydraulic soil control to increase food production (see also CLD in Fig. 6).

Figure 9 shows the main economic indicators: Produce and consumption per capita. It should be noted that this plot underlines the economic effects of city birth, but above all the consumption convergence of populations of the two former poles.

Figure 10 clearly shows conditions that lead to the crisis in the mining district (food shortage). When food available in the mining district is less than needed, the technician-

[45] Also the number of inhabitants of the simulated proto-city corresponds to what prominent etruscologists have estimated. The appendix of our previous contribution (Piattelli and Bianchi, 1998) includes such estimated values.
[46] I.e., when mining district population shows a value higher than the one computed at the previous time step of simulation.

princes decide to reorganize the Etruscan villages system founding the city. Population decrease (red line) – due to transfer from the mining district to the city – makes food balance positive again. It is worth to note that the jagged line representing food availability is due to random food production disturbances.

Figures 11 and 12 show population spatial distribution caused by the city birth. Fig. 11 deals with technician-princes, whereas Fig. 12 refers to industrial workers.

It should be noted that the sudden population decrease in the mining district has not been caused by deaths due to food shortage, but rather by transfer to the city.

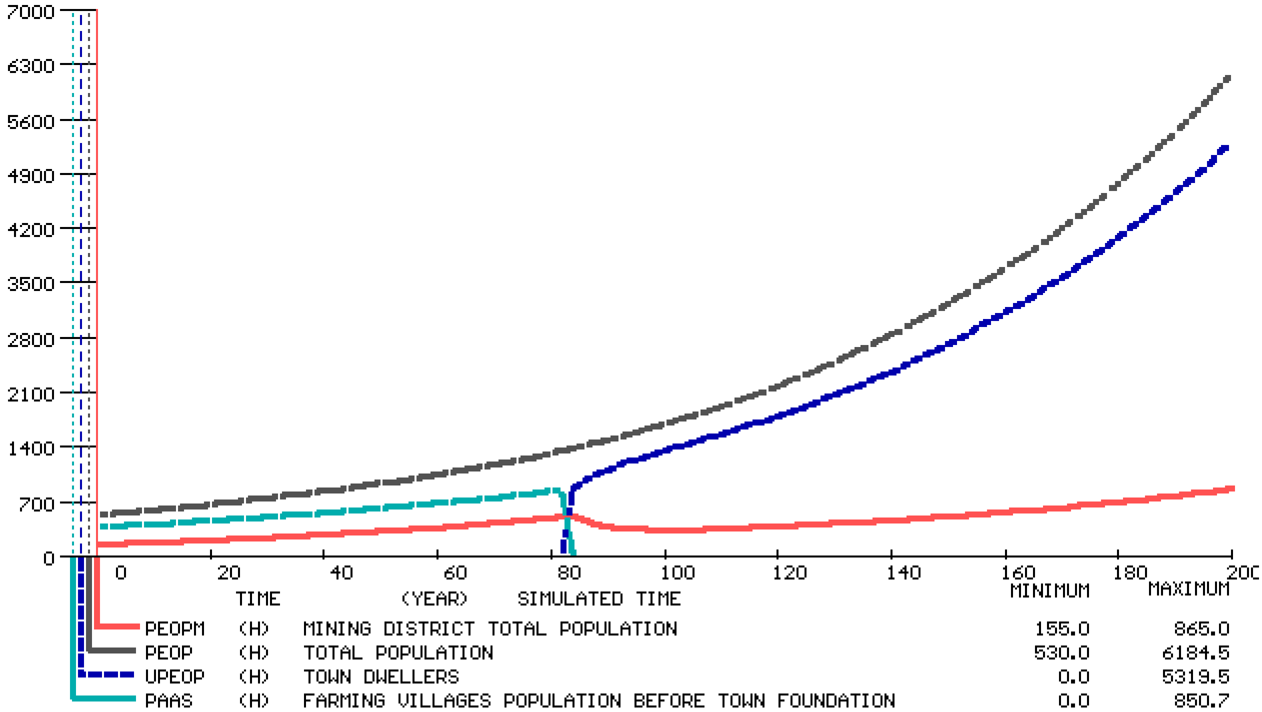

Fig. 7 – Population dynamics

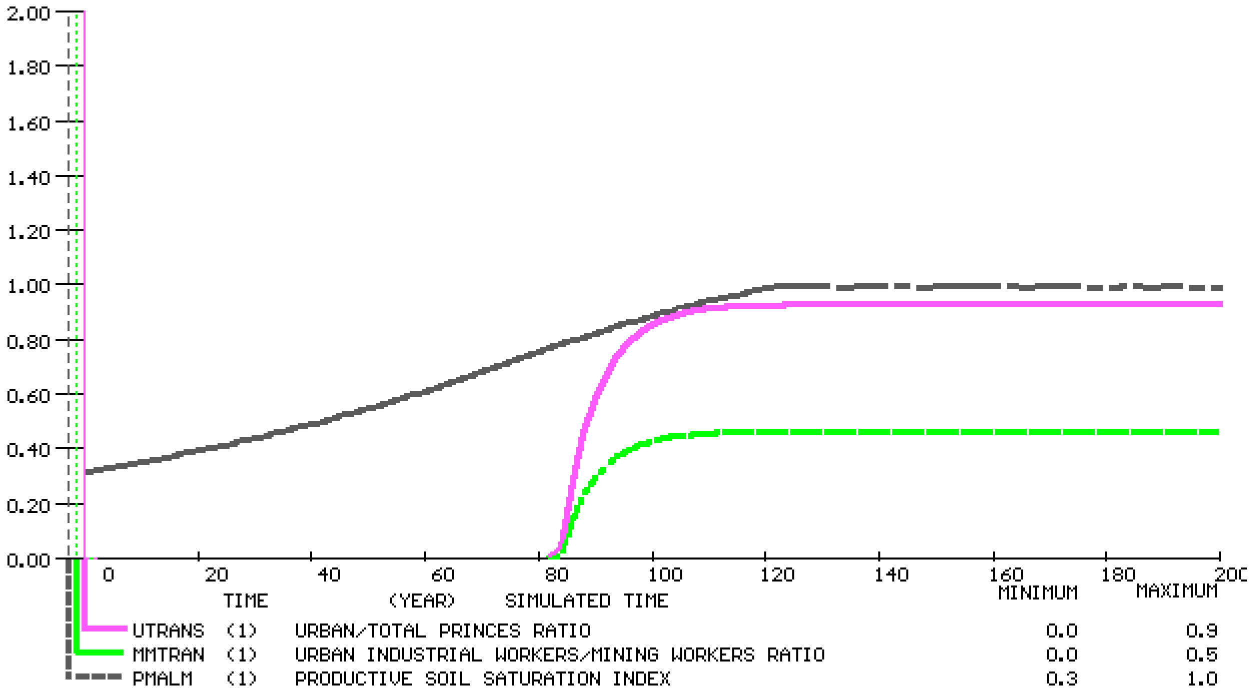

Fig. 8 – Dynamics of population transfer into the city

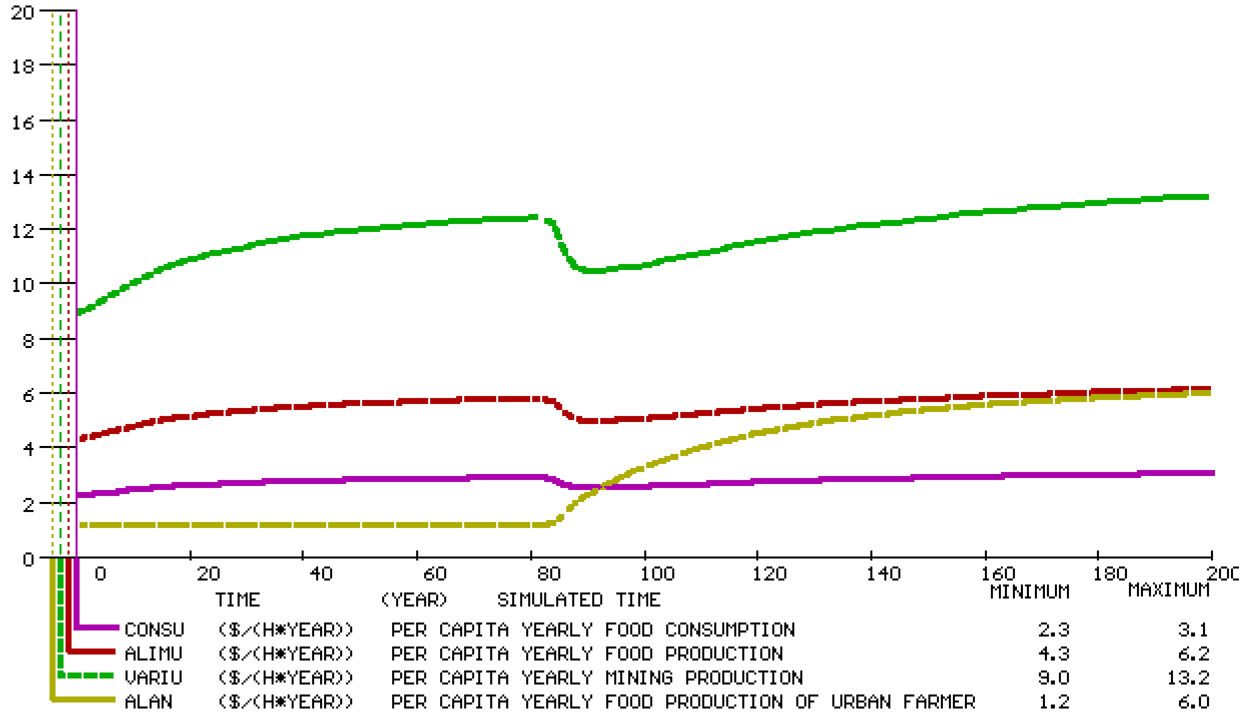

Fig. 9 – Socio-economic indicators

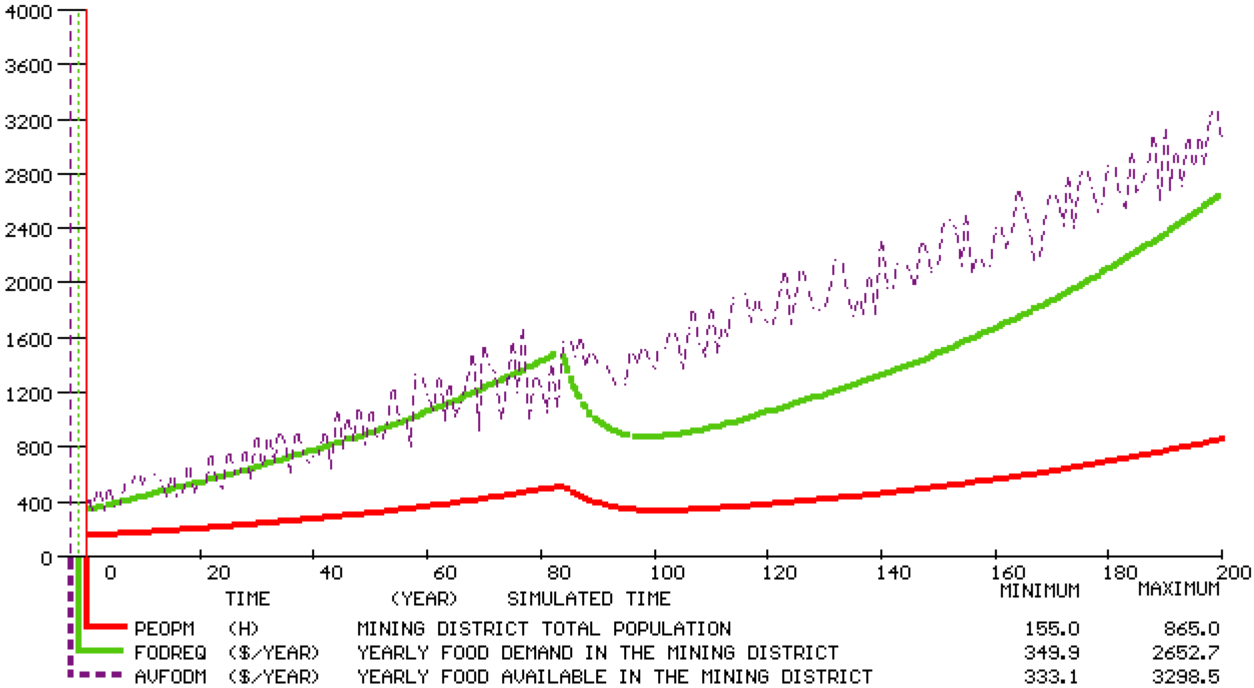

Fig. 10 – Conditions leading to crisis (food shortage) and its overcoming in the mining district.

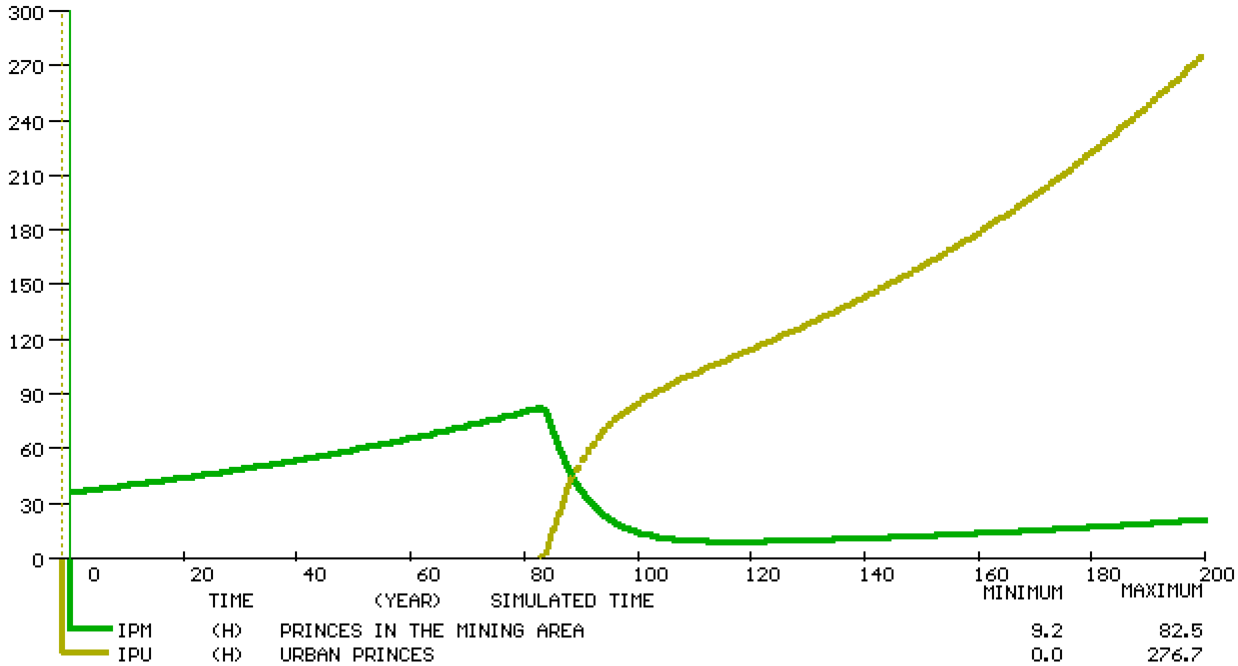

Fig. 11 – Dynamics of technician-princes distribution over mining district and the proto-city.

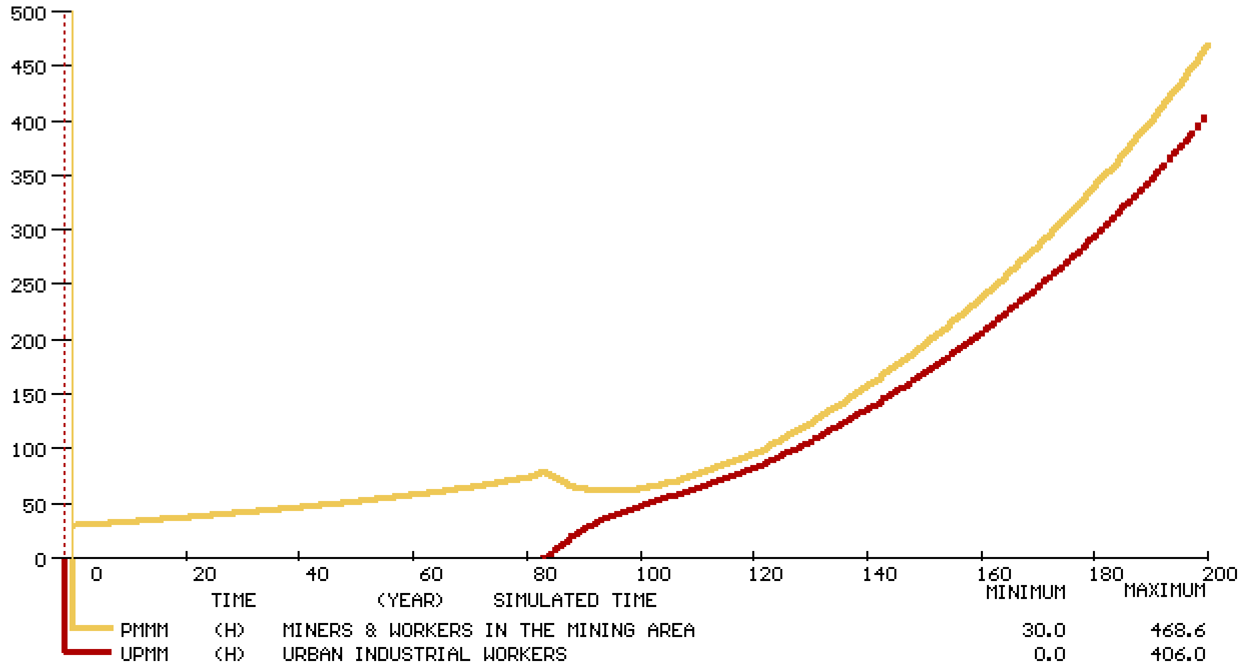

Fig. 12 – Dynamics of industrial workers distribution over mining district and the proto-city.

This illustrated example confirms that a model, formalized in a relatively simple way, allows simulating discontinuities of a city endogenous genesis, fitting the known historical reference behavior.

5. Endogenous or exogenous

Etruscan synoecism as has been described by current historiographical interpretation can undoubtedly be defined a pure endogenous process.

Instead, our interpretation of this process – which led to the foundation of early Etruscan proto-cities – includes a couple of external factors that made the transition possible. These elements deal with:

- Technicians-princes;
- population and activities of the mining district;
- interactions with the external environment.

Technicians who – in our view – led the process, belonged to a non-Indo-European population that bore an advanced culture[47] and settled in South Etruria a few centuries earlier.

Population and metallurgical activities of the mining district come into the city founded in the area of rural villages from an external territory, although not so far.

Increasing demand of minerals and goods from abroad, as well as possible immigration flows, that sped up the sustainability crisis which led to the city foundation.

[47] They not only possess mining and metallurgical skills, but also – contrary to rural village farmers – the concept of city.

Nevertheless, we still consider such a process as endogenous.

We have defined *endogenous* the described process because – taking into account the entire Etruscan system of villages and mines involved – the transition to the city concerns the same people and territory with no external contribution.

Interactions with the external environment only play a role in accelerating the instability crisis of rural and mining villages.

Technicians are indeed an exogenous factor, but it is a necessary condition for the success of the described process. A necessary condition analogous to the exogenous energetic supply, typical feature of self-organizing systems.

6. Further historiograpical remarks

It is proven that most Etruscan proto-cities built at the expense of rural villages appeared in South Etruria nearly at the same time. How should this event be considered? A casual phenomenon, or the same decision made independently in several territorial sites, or a case of imitation (namely, the perception of a new, better condition), or a strategic agreement among the territorial ruling groups?[48] Possibly, this happened because it worked, proving the rightness of the transition choice. But this answer does not clarify whether the event has been a shared choice of village headmen, or an operation imposed by mining technicians to pursue their power strategies.

Most likely, rural culture was rather backward and devoid of the germs that could help carrying out the transition. This last remark seems to corroborate our interpretation that early Etruscan proto-cities birth was driven by a social group that, although long resident, had been the bearer of an exogenous culture.[49]

The fact that mining areas did not uniformly spread on Etrurian territories might weaken the original part of our theory: The need of a reorganization within the industrial-mining pole as the main cause that favoured the city birth. Actually, some cities risen at that time had settled far from mining zones. A plausible conjecture on these rural cities, which does not question our speculation, ascribes their foundation to groups of foreign adventurers attracted by Etruscan prosperity and bearers of an ancient city culture; and, in other cases, to groups originated from the recently founded mining cities, and headed by princes in excess. Both groups sought their fortune in the far surrounding areas by imposing on indigenous villages, founding cities, whose economy was primarily agricultural and commercial: A sort of colonies of the mining cities. According to our hypothesis, these rural towns rose later than the cities founded near the mining districts, after a time interval not long enough to be determined by archaeological findings.

[48] The existence of an Etruscan league of 12 towns, called *duodecim populi Etruriae* (twelve peoples of Etruria) namely dodecapolis, is historically accepted. A legend, reported by Strabo, and partially by Herodotus, ascribes the foundation of these twelve cities to the mytical Tyrrhenus.

[49] See note n. 47.

7. Further methodological remarks

Our prevailing interest was not solely to communicate and validate our interpretation of the described historical event, but also to test simulation techniques to provide heuristics for this kind of modeling problems. The difficulty encountered in modeling the transition from villages to city concerns the discontinuity in a continuous dynamic system, implying compatibility between the dynamic system structural invariance and the emergence of a new organization inside the social system, which requires a different model structure.

Therefore, our study offers an example of how a dynamic system may handle discontinuities in social systems evolution, provided that the related pattern is known *a priori*. Besides, a successful implementation requires that arrangement and activation of the latent relationships be obtained with formal simplicity.

The proposed example deals with a transition from a lower organizational level – a village society – to a higher and more complex one – a city-state. Such a transition may be considered a process falling into the category of emergent structures.

Referring to Cruchtfield's (1994) classification, this case belongs to the first level on the scale of emergence, since the new organization results from a model expressly conceived to produce it. When evolution is known *a priori* this level appears consistent, since the focus is to identify the main causal relationships in the transition process.

The second level, to which deterministic chaos and morphogenesis (Pessa, 1998) belong, may be of interest for future development of this research project. Within the limits of dynamic system modeling, the self-organizing process proposed by Allen (1982) for social systems could be approximated by "stochastic re-causalization" (Mosekilde *et al*. 1983), in which morphogenesis spontaneity is obtained through causal structure modifications generated by random disturbances, while structure choice depends on a criterion of optimal system performance.

Nevertheless, it should be noted that when evolution is known *a priori*, this procedure also becomes deterministic, but its adoption allows at least refining the heuristics to handle discontinuities of future modeling projects.

8. Next steps

In the latest years, archaeological excavations have been carried out, and are still under course, in the geographical areas of Etruscan settlements – particularly on urban areas of interest for this contribution. Information and data emerged from these researches will be very important for building reference modes apt to validate our model.[50]

The model illustrated herein needs to be further developed, also by reducing its generality for several reasons:

- Disaggregation of few macro-variables would favor the emergence of factors, such as hydraulic soil control, which play an important role within our historiographical interpretation;[51]

[50] According to Randers (1980, § 6.4), reference mode is the key element to define model structure. Guidelines exist to conveniently build it, both as a learning process (Saeed, 2001) and as handling numerical time series (Hovmand, 2003). A particular aspect of this research (human groups dynamics) may suggest the usefulness of building also a spatial reference mode (BenDor and Kaza, 2012).

[51] Such factors do not appear as variables in the source code list, but are considered aggregated to some performance parameters. Such a disaggregation is not strictly needed from a functional point of view, but could help to better communicate our model and consequently our historical interpretation.

- more acquired details would improve the model communication value, allowing interested scholars to achieve a better grasp of the model (and of the historical interpretation), and potential collaborators to intervene more easily on the model;
- adding some variables and parameters that account for geographical and “cultural” conditions, should help solving some historiographical critical points;
- a desirable upgrade to second level in the classification of emergences (Cruchtfield, 1994) seems to require just a reduction of *conceptual distance* in the model, since the current formal structure has the potential features to climb the step.

Specific analysis procedures, optimization techniques and validation tests will be applied to the new model, in order to prove its conformity with the known events and to provide useful information for historiographical research.[52]

Along the guidelines drawn by Rahmandad and Sterman (2012), the model will take care of all aspects of documentation and transparency (Martinez-Moyano, 2012) to make its communication easier, favor discussions with experts in the field, and allow their involvement in further model developments.

As a further test of our hypothesis on the genesis of early Etruscan proto-cities, a comparison between contrasting models could be used as an evaluation procedure,[53] defining its criteria on the basis of robustness, conformity with real data available, and a higher number of data “explained” by the model.[54]

Our research project could also take advantage of some form of collaboration with experts in other methodological approaches. A *multi-agent based* model (Cecconi *et al*., 2004) dealing with the birth of early Etruscan proto-urban centres has achieved excellent results, reproducing the diffusion of population groups on surrounding territory, their capacity to control the territory, the available resources, and orographic constraints for their movements. Converging results expressed by an aggregate *top-down* model (the SD one) and by a highly disaggregated *bottom-up* (*agent based*), may become an excellent corroborative factor for a historiographical interpretation.[55]

Besides, presentation of the improved model will stress and explain in detail several aspects of the methodological approach proposed herein, of which historians could benefit in their research activity.

The historical event discussed in this paper presents a strong characterization from the point of view of social and environmental sustainability and could become a paradigmatic example, like the collapse of the Maya (Hosler *et al*., 1977; Forest, 2007)

[52] The procedures of design of experiments (DOE) (Kleijnen, 1998), implemented within our virtual laboratory, range from calculating the right number of replications of simulation runs to ensure confidence in the results when random disturbances have been inserted into the model (Law e Kelton, 1991), to automatic calibration of parameters (Oliva, 2003). Among several procedures, sensitivity analysis play an important role because, singling out critical interval of parameters and initial values, may provide useful information to orient field research (archaeological excavation campaigns and sources). All these procedures help to reduce the risk that models become only a plausible nonsense, as recalled by Coyle (2000) – paraphrasing Nuthmann (1994) – criticizing a Maya collapse model (Hosler *et al*., 1977).

[53] In our case, an antagonist model deals with the current historiographical interpretation that leaves out the most original aspects of ours (sustainability crisis, industrial sector reorganization, event forced by technician-princes), giving instead priority to reasons of defense and protection. Then, the competing dynamic hypotheses will be tested to verify whether their conditions are both necessary and sufficient for the foundation of the proto-city.

[54] Details on comparison methodologies and techniques can be found, for instance, in Goldsman and Nelson (1998).

[55] It should be noted that the cited *multi-agent* model does not take into account any hypotheses of our interpretation.

and Easter Island (Sterman, 2000, pp.125-127; Diamond, 2005; Turkgulu, 2008) populations. This pedagogical-educational metaphor could be strengthened by a gaming version of the model, that would become a learning environment.[56]

9. Conclusion

A sustainability crisis of a socio-economic system of the Past, solved by the birth of a city-state, has been presented by means of a dynamic simulation model. It deals with a rather original interpretation of the Etruscan synoecism through dynamic hypotheses disregarded by current historiography. In our interpretation, the city birth represents the "necessary and sufficient" tool for a social and economic reorganization capable to recover sustainability and strengthen the power of the ruling class of technician-princes. In other words, the city is the tool which allows to govern.

The developed model roughly fits a reference mode not easy to outline by the poor data and information on that remote historical segment, showing consistency between premises – the described dynamic hypotheses – and conclusion – the system behavior.

The city birth event represents an evolutionary discontinuity in the Etruscan civilization path, an organizational change for a territory which included rural and mining villages; and for the model it becomes a matter of structural change that has been solved by the inclusion of a second predetermined structure. The fully documented model becomes a further example of handling discrete events – particularly evolutionary discontinuities – within a hybrid simulation environment.

The model may also be a basis of discussion to promote a less conventional manner of debate on Etruscan synoecism,[57] and intends to again suggest the M&S approach – particularly SD – as an auxiliary discipline of History. In fact, this contribution tries to demonstrate how systemic vision and M&S approach may cast a more penetrating light on remote events.

Finally, the next steps in this research project have been illustrated above to ensure that what has been presented in this paper does not remain an exercise of retrodiction or a mere cultural curiosity, becoming an effective, efficient implementation for historians.

10. Supporting information

The fully documented source code of the model is available and may be found in the supporting materials section of the 2013 ISDC web-page.

The four images of CLDs have been added as graphic files for a better visualization.

11. Acknowledgements

The herein expounded interpretation of the Etruscan proto-cites genesis has been originally enunciated by Mauro L. Piattelli. The authors followed in his wake and are very grateful to him.

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[56] An introduction to SD learning environments can be found, for instance, in Morecroft (1992) and Langley and Morecroft (1996).

[57] Actually, our model has the same function of a concept model (Richardson, 2006; *id.*, 2013), with the same aims.

12. Credits

The table of city names and the map of Etruscan civilization have been taken from Wikepedia and released under the terms of the GNU Free Documentation License.

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