Institutional Change in Property Rights: Model and Evidence of a Centuries-Long Dynamic [1]

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Abstract

We provide a model that describes the progressive closure of more affluent societies to immigration to protect the wealth of insiders. This closure took the institutional form of patrilineal property rights. We show how this institutional change can emerge locally, spread by contagion, and generate a situation where societies are locked into a gender-biased society. Only a centralized, top-down intervention could restore gender equality in property rights. This pattern is presented through a model and exemplified through evidence of institutional change in communities in the Italian Alps, where inheritance institutions over common property resources evolved over six centuries (1200-1800). Through historical data and a computational model, we uncover the mechanisms for the path of the gradual transition from an egalitarian to a patrilineal institutional regime, followed by the sudden reinstatement of an egalitarian regime via a centralized decision.

Keywords: contagion; lock-in; commons; gender.

JEL: J16; N53; Q20.

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1. Introduction

We argue that societies tend to close to the outside world when their economic resources are under threat. Picture a world comprising multiple societies that are all open to immigration. On the opposite end, consider a world where nobody accepts migrants. We present a historical situation with a decentralized, gradual transition from an open to a closed world and a later centralized, wholesale switch back to an open world. Based on empirical evidence, we argue that there are strategic reasons behind this asymmetry in transitions: the defensive closure -- one community at a time -- progressively creates a situation where everyone is locked into a closed world; and, only a top-down intervention can restore an open world.

We illustrate this dynamic through the empirical evidence of institutional change in community governance of the commons during the Modern Age. The common property resources (CPRs) and its governance institutions have been extensively studied especially after the work of Elinor Ostrom (Baland and Platteau, 1996, Bromley, 1992, DeMoor et al., 2002, Gibson et al., 2000). We observe the endogenous and progressive closure of communities in a region of the Italian Alps (Casari and Lisciandra, 2016). The migratory pressure on more affluent communities generated a reaction to dissuade strangers from moving in. In these communities, women progressively lost their rights to access the commons: those women who married a man from another community lost their rights to exploit the commons and to transmit by inheritance any property rights over them.

To gain insights into this phenomenon, we build a model of the interactions among several communities within a district, each one with jurisdiction over their local commons. The underlying forces that shaped the institutional change may be at work also in other settings. Consider, for instance, issues of citizenship rules and migration across nations, where a citizen enjoys benefits from her nation's social and economic capital. Many of these benefits are tied to living in a specific location. When moving, benefits are lost without any compensation. Think about law and order, the welfare state in terms of primary schools or basic health care, access to a lucrative job market, and public goods like clean air or public parks. By migrating, a citizen loses these benefits in the nation of origin. Like in our historical case, the migrant citizen cannot sell her citizenship rights to others. Nor she can sell the above benefits that she no longer consumes after moving. Depending on the access rules, she may be able to access these benefits in the nation of destination to some degree. In generalizing this model, the key aspect is the extent to which these benefits are rival in consumption. Clean air is obviously not rival, but health care under a fixed budget can be.

The model is computational, and the reason is that it embeds algorithmic routines that are difficult to model analytically. We use a matching algorithm to pair men and women, the Gale-Shapley algorithm (Gale and Shapley, 1962), which is notoriously problematic to write up in equations. When modeling a sequence of generations, individual traits are transmitted from parents to children. This aspect is also difficult to capture in a closed-form analytical model. The computational model serves the same purpose as an analytical model. It is not meant to be a simulation exercise that exactly reproduces the field data but rather a tool to demonstrate the mechanisms and principles that could drive the institutional change in the historical situation.

One strength of this paper is the availability of detailed historical documentation about the path of institutional transition and a dynamic theoretical explanation. There is vast empirical literature on the impact of distant past events on current outcomes (Tabellini, 2010, Alesina et al., 2013, Guiso et al., 2016). However, the evidence often rests on the comparison of two points in time, in isolation. Usually, the transition process that leads from the past to the current outcomes remains undocumented. Consequently, any theoretical explanations cannot be tested using the evidence about the transition, as it can be done instead here. Another strength is its very long-time horizon. Tracing institutional change over six centuries allowed us to identify a pattern that could have been easily missed even with a time window of fifty or one hundred years.

The paper proceeds as follows. Section 2 puts forward the historical evidence, while Section 3 presents the main historical patterns of institutional change. In Section 4 we describe the computational model, and then outline the results and predictions from the model in Section 5. Section 6 discusses the model predictions and presents additional historical patterns. Finally, Section 7 concludes.

2. The historical and institutional setting

This section provides some background information about the Trentino region in the Italian Alps. In this region, a decentralized, endogenous institutional change took place during the Middle and Modern Age. In the thirteenth century, women enjoyed equal rights on collective resources, but by the end of the eighteenth century, inheritance rights on CPRs became patrilineal. Interestingly, property rights on private land followed a different trajectory (Casari et al, 2019). The literature on inheritance deals, almost entirely, with private property, but we will show that the consequences of patrilineal inheritance on common property are drastically different.

The Trentino region is situated in the Italian Alps at the border with South Tyrol (Cole and Wolf, 1974). The region is mountainous with the presence of about 366 villages, usually with a few hundred

inhabitants. The administrative center, Trento, was a small town (11,989 inhabitants in 1810). About 28% of the villages were more than 50 km from the capital town scattered through a rugged landscape. About 73% of them were situated at an elevation above mt. 500 a.s.l.. The weather exhibits marked variations across different seasons and altitudes, with snowy winters. The arable land was limited to only 8% of the surface (Consiglio provinciale d'agricoltura pel Tirolo, 1903) due to the high altitude, as 70% of the land above mt. 750, and its steepness.

The cornerstone of the present analyses are property rights on common property. In this respect, some salient features appear. First, common properties were extensive and quite valuable. Our data suggest that CPRs accounted for about 58.5% of the whole surface and about 25% in value (Casari and Lisciandra, 2016).[2]

Second, the commons were essential for the villagers' survival. There was a limited degree of substitutability among private and common land. The two resources were complementary goods. Typical produces in this Alpine region were grapes and grains, mostly cultivated in private lands, while forests, meadows, and pasture were under the community property. Most of the common land was grazing land, pasture, and especially forest. Forests provided the essential energy source, such as firewood, timber for building and crafting, litter for animals. The private property consisted mainly of houses, gardens, and arable land and showed seasonal complementarities with communal land: during summertime, cattle grazed in the high mountain pastures, while during wintertime, they were kept in private stalls and fed with the hay collected from communal lands.

Third, the endowment in common property differed widely across villages, mainly due to the region's orographic characteristics. The inequality in per-capita collective wealth across villages in a subsample of villages for which data is available is relatively high (Gini index=0.61), actually higher than the inequality in the distribution of private and collective wealth combined across villages (Gini index=0.27).

Fourth, a key issue for welfare was avoiding the tragedy of the commons (Gordon, 1954, Ostrom, 1999). The governance regime present in these communities fits the classification of self-governance institutions of Elinor Ostrom (Ostrom, 1990). Starting from the thirteenth century, many communities in the region redacted local charters (*Carte di Regola*) to define and enforce property rights on collective forest and pasture. These charters were official deeds, where community members formalized the rules for the management of CPRs. This system of governance is similar to the one found in the Swiss Alps (Netting, 1972, 1981). The first charter found in the archives dates 1202 and

[2] These estimates are based on a sample of 32 villages from the 1780 (Theresian) cadastral register.

the last one 1796, with added chapters stretching as far as 1801. By the end of the period, about 82% of the villages had adopted a charter. The system abruptly ended shortly after 1796, when Napoleon seized the region. Its definitive removal took place in 1807 (O'Grady and Tagliapietra, 2017).

To study inheritance on the commons, we need to focus on membership rights. Only community members (*vicini*) had property rights over the commons and shaped governance rules. More specifically, benefits from the local commons went only to those with membership that lived in the community. Both conditions were necessary. For instance, if a member moved out of the community, she could not claim benefits. When moving, a member could not sell her membership either, but would simply lose it. Membership could be acquired by inheritance.[3] Long-term residence, or being born in the village, per se, did not entail the right for membership. The property rights extended to everyone in the household: if both wife and husband were members, or just one of them, it made no difference in the amount of benefits. Most of the benefits of a household were independent from the number of the people living under the same roof.

This paper relies mostly on Casari and Lisciandra (2016) for evidence about institutional change, and comprises the coding of more than 500 historical documents for the years 1202-1801.[4] Evidence about inheritance systems on the commons were extracted from those documents, if and when present. With few exceptions, these documents were charters, engrossed by a notary on behalf of community members and promulgated by the Prince of Trento. The charters did not embody a systematic set of rules governing the relationship between peasants and economic resources, but were rather an instrument addressing contingent issues. Over time, the enactment of a new charter could be followed by several modifications once a controversy was to occur.[5] Therefore, charters or their modifications with additional chapters encoded inheritance rules once previous informal rules became dysfunctional and needed to be superseded by new commonly recognized rules.

3. Main historical patterns of institutional change

We report two main patterns of institutional change in the inheritance system on the CPRs. They constitute the empirical starting point of this research project.

[3] In some instances, membership could also be bought from the community (not the single member) subject to the approval of the members by supermajority votes.

[4] Specifically, the database provided 878 entries subdivided as follows: 480 charters, 339 relevant additional chapters that are posterior to a charter's promulgation, 59 other legal documents.

[5] For a study about the emergence of these charters as a way to formally govern the commons, see Casari (2007).

Historical pattern 1: Institutional change toward a closed system. The available evidence indicates that, in the Medieval period, the inheritance system on the commons of Trentino villages was egalitarian (Casari and Lisciandra, 2016). The formalization of inheritance systems in written documents occurred in 87 villages. Some villages changed over time the inheritance system specified in their first formalization. In all recorded changes, there was a shift towards more gender-biased inheritance systems. In several cases, this transition occurred in multiple steps as villages temporarily adopted a soft-patrilineal system where families with only daughters and no sons could transmit membership to one or more daughters. At the end of the XVI century, 11 villages transitioned from an egalitarian inheritance system to a soft-patrilineal system, and, over time, the same villages, along with other eight villages, transitioned from a soft-patrilineal system to a patrilineal system. The vast majority of villages (64) transitioned from an informal egalitarian system to a patrilineal system. At the end of the period, 82 villages had a patrilineal system, three had a soft-patrilineal system, two had the Erbhof system, a variant of primogeniture inherited by the German tradition, and none had an egalitarian system. Thus, the evolution of inheritance rules was essentially unidirectional, going from equal membership rights for men and women toward increasing gender discrimination.[6]

Three observations may better place this pattern into context. First, the inheritance system on private land and assets remained egalitarian, although girls may have received a lower amount than boys (Casari et al, 2019). Second, during the six centuries under study, the primogeniture system of inheritance played a very marginal role in this region. Third, the observed pattern may be more general, as similar restrictions in the property rights for women emerged also in other parts of Italy (Alfani, 2011).

Historical pattern 2: A centralized intervention restored an open system. In Trentino, the Napoleon invasion of 1796 brought the charters experience to an abrupt end. Within a few years, the central government removed all ancient regime institutions. The suppression of charters took place in the years 1805-7. The new regime that replaced the charters' system regime exhibited two significant differences (Casari et al., 2019). First, women discrimination in accessing the commons was abolished, and inheritance on the commons became de facto egalitarian for all communities. Second, the previous decentralized decision system was replaced by a centralized government that did not allow local variations in inheritance rules. Thus, the right of each community to locally establish and discretionarily change inheritance rules on collective resources was suppressed.

[6] In contrast, the evidence does not show a shift toward a patrilineal system for the inheritance system on private land (Casari and Lisciandra, 2016).

4. Computational Model

Consider the following model. A district comprises K communities, and every community k=1, ... , K has an endowment W_k of commons. Each community independently sets the rules for the governance of their commons. Access to the community's commons is based on the membership right, which is inherited from parents. Each community can choose its inheritance system on the commons to be either egalitarian or patrilineal. In an egalitarian system, both men and women can inherit community membership, transmit it to all their offspring, and establish their own families with full rights to access the collective resources. In a patrilineal system, only men have these rights.[7] Residency and membership are distinct. Individuals from other communities that acquire residency in another community have no access to the incoming community's commons unless they marry a member of that community.

Within this simple framework, we set up a computational model that traces a district's evolution over time in terms of population, wealth, and governance of the commons (i.e., the commons' inheritance system). The model considers a district with a total of K=7 communities. Time is structured in generations. For the first generation, communities have the same population (n=110) but different endowments of commons W_k. The initial endowment of commons is a random draw from a uniform distribution with $W_k \sim$ U[0,220] and remains constant over time.

The population of each community is balanced by gender. Everyone in a generation marries, and each couple will have exactly two children, one son and one daughter. Hence, the district population remains stationary and balanced in gender, although specific communities' population size can vary because of migrations. Generations do not overlap as each couple is replaced in the next generation by precisely one boy and one girl. Couples are formed through a matching process within a generation that is broken down into rounds. In each round, only a cohort of the overall population participates in matching. In the first generation, each cohort comprises ten individuals from each community for a total of 70 individuals matching (about 9% of the population, half men and half women. Therefore, the matching process by cohort requires overall 11 rounds to allow the whole population in a generation to match. In the following generations, each cohort comprises 70 individuals again, although the number of individuals coming from a specific community may vary depending on its overall population. It could help see a cohort representing a five-year age group of the population, where individuals are assumed to have a lifespan of 55 years.

[7] The right to access as well as the share of collective wealth is family based, regardless of the numerosity of the family and the number of members living under the same roof.

We set the number of generations equal to nine. Counting eleven rounds for each of the nine generations, time in the model amounts to a grand total of 99 rounds. After every round, the model updates the community population and the per-capita level of collective wealth, w_k. Given that the commons endowment is fixed for a community, w_k obviously declines as more people have access to the commons. Moreover, after every round, institutional change can take place, as the community may switch the inheritance system on the commons. After every eleven rounds (i.e., one generation), the renewal occurs, and a new generation of individuals with new traits substitutes the old one.

The traits of an individual are two. One is his or her level of personal attractiveness (a) -- either physical, moral, or private wealth -- and the other one is the relocation cost (c), which is the cost to move away from the current community of residence. In the model, personal attractiveness is quantitatively the dominant element in the choice of the partner. It includes ownership of private land, where inheritance always remains egalitarian. Relocation costs capture the cost to sell personal assets that are not mobile and relocate to another community. Losing the support network from one's community is also part of the relocation costs. Although the model assumes perfect information about potential partners, the relocation costs may also indirectly capture the difficulty of meeting and knowing people outside the community.[8] The cost is assumed to be equal for all destinations outside the individual's community and does not depend on distance. In short, the model assumes global interaction across communities within the district, with some friction due to a cost parameter.

Each trait is initially assigned through an individual random draw from a uniform distribution, which is U[0,20] for attractiveness and U[0,4] for the relocation costs. Individual attractiveness and relocation costs are reassigned after each generation: 75% of the trait is inherited from parents, and 25% is random.

$$a_{child} \equiv 0.375 \cdot a_{father} + 0.375 \cdot a_{mother} + 0.25 \cdot random(0,20)$$

$$c_{child} \equiv 0.375 \cdot c_{father} + 0.375 \cdot c_{mother} + 0.25 \cdot random(0,4)$$

Parents have equal weight in transmitting personal traits. Attractiveness and relocation costs are *i.i.d.*, i.e., statistically independent from the random draw of community wealth and each other. The reason why relocation costs are similar to those of one's parents lies in the path dependency in the social support network within a specific community and the specific degree of mobility of inherited assets. About marriage, individuals can freely choose whom to marry, and simultaneously the couple chooses where to live.

[8] While the current model treats all communities as equally distant, an alternative model could instead have a parameter to explicitly consider the distance between any two communities in order to give more importance to closer rather than to far-away communities. This parameter would affect interaction, for instance by making moving costs increasing in distance. This variation in assumptions may better capture the different frictions that a person experiences in marrying somebody outside his or her community in terms of poor information about personal traits, disruption of social networks, transportation, and costs to cash illiquid assets.

Whom to marry. The individual *i*'s choice about whom to marry depends on several elements. Everyone desires to get married and has identical preferences about partners, $U_i=U(a_j,w_k,c_i)$. We assume that the utility functions are additive in three components. Specifically, the utility of individual *i* and that of his or her potential partner *j* are:

$$U_i \equiv a_j + 2w_k - c_i$$

$$U_j \equiv a_i + 2w_k - c_j$$

Personal attractiveness of spouses is captured by a_j and a_i. The component w_k is the per-capita collective wealth of the community *k* in which the couple will settle down. Each agent suffers from his or her relocation costs, c_i and c_j, respectively. As we will see, only one individual in the couple relocates. Hence, if *k* is the *i*'s community, then *j* suffers from c_j, and vice versa.[9] If both individuals come from the same community and decide to stay, none of them has relocation costs.

The individual-level interaction follows a two-sided matching model with transferable utility among partners, with no search costs but with relocation costs. Couples are formed following the deferred acceptance algorithm (Gale and Shapley, 1962). In a nutshell, this algorithm processes proposals such that most preferred individuals match first, while less preferred (rejected) individuals match subsequently until all individuals form a couple. We need to assume that men make proposals first; however, the outcome would not change if women were to move first.

Where to live. Recall that the decision about where to live is concomitant with the choice of the partner. In principle, individuals can move to any community in the district; in practice, the choice is between the man or the woman's community. The reason is that individuals have no access to the commons of communities in which they are not themselves members. Hence, settling in any community except where the couple can enjoy membership is a dominated choice. If both partners come from the same community, they stay where they are. If they come from different communities -- and relocation costs are the same for both partners -- they will usually prefer the community with the highest per capita wealth but will factor in relocation costs.

Inheritance system on the commons. The inheritance system on the commons plays a crucial role in the choice of where to live. In the current investigation, we consider three scenarios: (1) all communities have an egalitarian inheritance on the commons; (2) all communities have a patrilineal inheritance on the commons; (3) In round one, all communities have an egalitarian inheritance; at the end of round one or in the subsequent rounds, a community will switch to a patrilineal system if its per-capita endowment of commons falls below a fraction of its initial (round 1) value. We refer to this

[9] Notice that w_k is multiplied by 2 because the number of individuals eventually deciding to live in a community is always even and the share of collective wealth that partners can enjoy is family (couple) based, such that either both partners are members or one of them is a member, then the share is the same.

fraction as the threshold for institutional change (0.7). The model keeps track of the evolving population in each community to update the per-capita collective wealth after each round. For patrilineal communities, it also keeps track of the number of members as well.

To sum up, we provide an overview of the parameters of the computational model:

a) the threshold for the institutional change in a community (default H=0.7);
b) the distribution of commons endowment (default W_k~U[0,220]);
c) individual attractiveness (default a~U[0,20]);
d) individual relocation costs, (default c~ U[0,4]);
e) percentage of transmission of individual attractiveness and relocation costs from parents (p=0.75).

Attractiveness is on average ten times higher than w_k, while relocation costs are on average twice as high as w_k. The yardstick in these assessments is the initial level of per-capita collective wealth w_k=W_k/110.

5. Model results

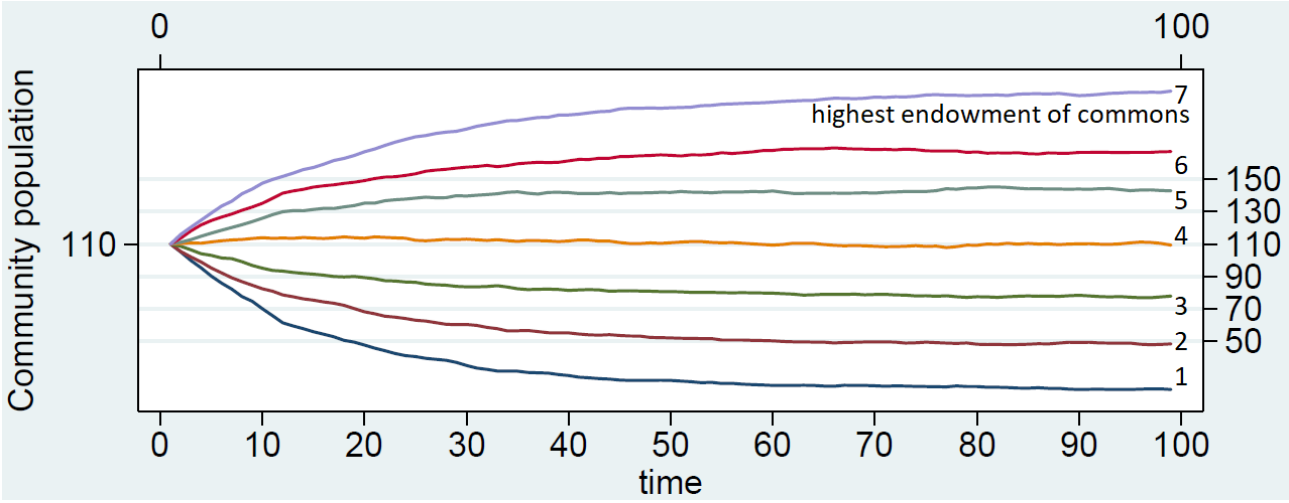
As a benchmark, we put forward the model results from two extreme hypothetical scenarios without institutional change, where communities are either all egalitarian or all patrilineal and remain as such over time. In the model, each community's population is initially set to be the same and then individuals move across communities over time. Figure 1 shows the average population of each community in the two scenarios. Under an all egalitarian system on the commons, individuals want to migrate from the relatively poorer communities in terms of per-capita collective wealth toward the relatively richer communities. The average population across communities diverge over time (Figure 1a). One scenario of the model considers a district of 7 communities interacting over time, where a single run constitutes an independent unit of observation. Time is structured in nine generations, where one generation comprises 11 cohorts, such that the total number of rounds is 99. The seven lines in Figure 1 correspond to the different communities ranked in terms of the initial level of collective wealth (7=richest community, 1=poorest community).

As a consequence of migration across communities through marriages, the inequality in per-capita collective wealth tends to decrease. In particular, under an all egalitarian inheritance, the average standard deviation goes from 0.55 in round 1 to 0.07 in round 99. This outcome contrasts with the results from an all patrilineal inheritance system (Figure 1b), where net migrations across communities

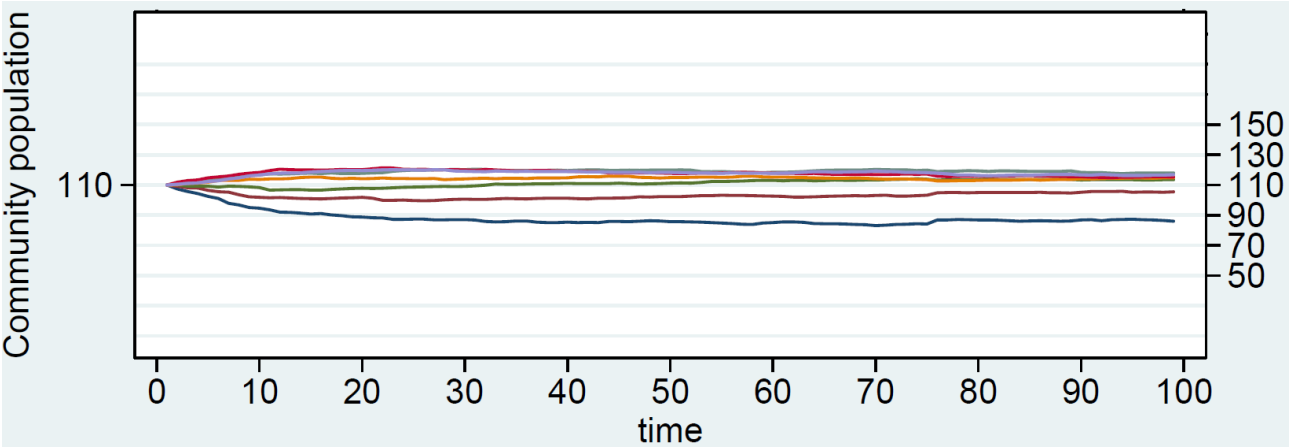
are low, and the average standard deviation of the per-capita collective wealth is only slightly reduced to 0.53.

Figure 1. Population by community without institutional change.

(a) *All egalitarian inheritance*



(b) *All patrilineal inheritance*



Notes: Communities are ordered from 1 to 7, according to the initial per-capita collective wealth. Time unfolds over 9 generations, which encompasses a total of 99 rounds. An observation of the community population in a round is the average over 20 runs. The computational model results are based on data from a series of runs using different random seeds.

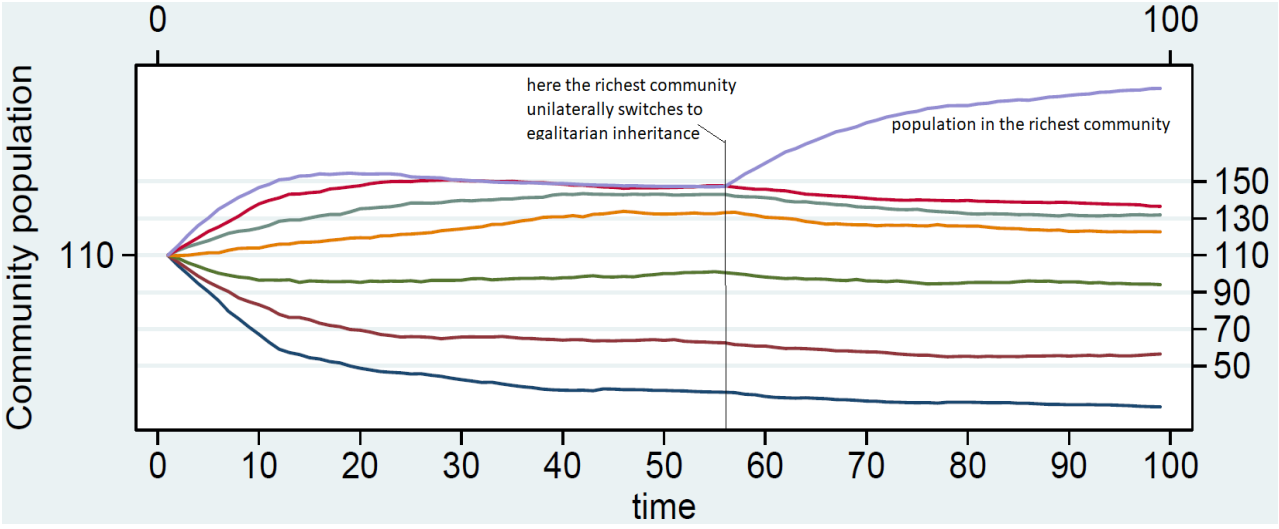
In the remaining part of the section, we focus on the scenario where institutional change can occur; each community can autonomously switch from an egalitarian to a patrilineal system. In the model, there is an interplay between inequality, migratory pressure, and institutional change. When institutional change is possible, the inequality in per-capita collective wealth also tends to decrease but to a lower extent than in a district with all egalitarian communities. In particular, the average standard deviation of per-capita collective wealth goes from 0.57 in round 1 to 0.23 in the last round, when communities can switch to a patrilineal system, while plunges to 0.07 when institutional change

is not allowed. To be more precise, immigration brings a decline in per-capita collective wealth in a community, and this can trigger an institutional change when the per-capita collective wealth goes below a threshold of H=0.7 of the initial value. In many communities, we observe an institutional change as a switch from an egalitarian to a patrilineal system between rounds 1 and 99.

At the end of this process, communities are locked into a patrilineal system because reversing institutional change through decentralized decisions, one community at a time, could be very costly for the insiders of the single community. The reason is that in a district with all patrilineal inheritance if a community unilaterally reverts to an egalitarian inheritance system, it will face enormous immigration pressure from other communities, as it is the only open community.

Consider the baseline scenario where institutional change is possible. We start with an all egalitarian district, and communities can undergo institutional change toward a patrilineal inheritance, up to round 55. By that time, the richest community has almost certainly turned patrilineal. We introduce a breaking point at round 55, where one community, the richest, exogenously reverts to an egalitarian system and stays that way for the remaining time (Figure 2). In this hypothetical scenario, the richest community's population quickly increases, lowering the per-capita collective wealth of the original community members.

Figure 2. The richest community unilaterally switches to egalitarian inheritance.



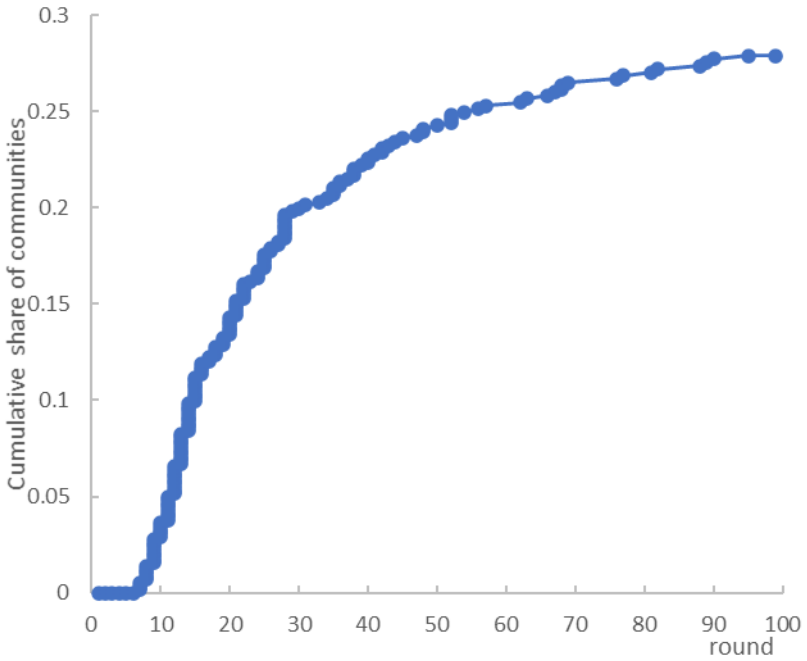
The model makes various additional predictions. Here we list five.

A) Institutional change most likely occurs in a minority of communities. In a district of 7 communities, on average, 2.7 switch from an egalitarian toward a patrilineal inheritance system, representing 39%

of communities. In 78% of the runs, a majority of communities remained egalitarian. What drives institutional change is the presence of a component of collective wealth. When communities have no collective wealth at all (W=0), the model shows no institutional change. As illustrated later, the patterns of institutional change are closely related to communities' collective wealth, in terms of which community switches, their speed, and intensity. The actual fraction of communities that switches to a patrilineal system depends on the choice of the threshold. The lower the threshold, the less frequent is institutional change. If the parameter is extremely low, for instance, corresponding to a 65% reduction in the initial per-capita collective wealth (H=0.35), no institutional change is observed.

B) The dynamic of institutional change is not linear but proceeds in phases. After an initial delay, institutional change starts at a fast pace, then slows down, and eventually stops. Figure 3 describes the cumulative number of institutional changes round after round over 60 runs. In the first rounds, the migratory pressure mounts, but no institutional change occurs (rounds 1-7). After this lag, there is a second phase with a sudden acceleration of switches from egalitarian to patrilineal inheritance (rounds 8-13). The process continues in a third phase, but the speed gradually slows down until it eventually stops (14-99). Hence, over time the cumulative share of communities undergoing institutional changes follows an S-shaped curve.

Figure 3. Institutional change follows an S-shaped curve.



C) No institutional change occurs when individuals have very high relocation costs (c=*40* vs. c=*4* in the baseline run), which makes them very unwilling to relocate to other communities. This outcome

suggests that there would be no institutional change from egalitarian to patrilineal without geographical mobility in a society.

D) The type of communities that switches and the timing of switches are not random. The poorest community in terms of per-capita collective wealth never switches to patrilineal, while the richest one almost always does (Table 1). More generally, the community rank in terms of per-capita collective wealth systematically predicts institutional change frequency.

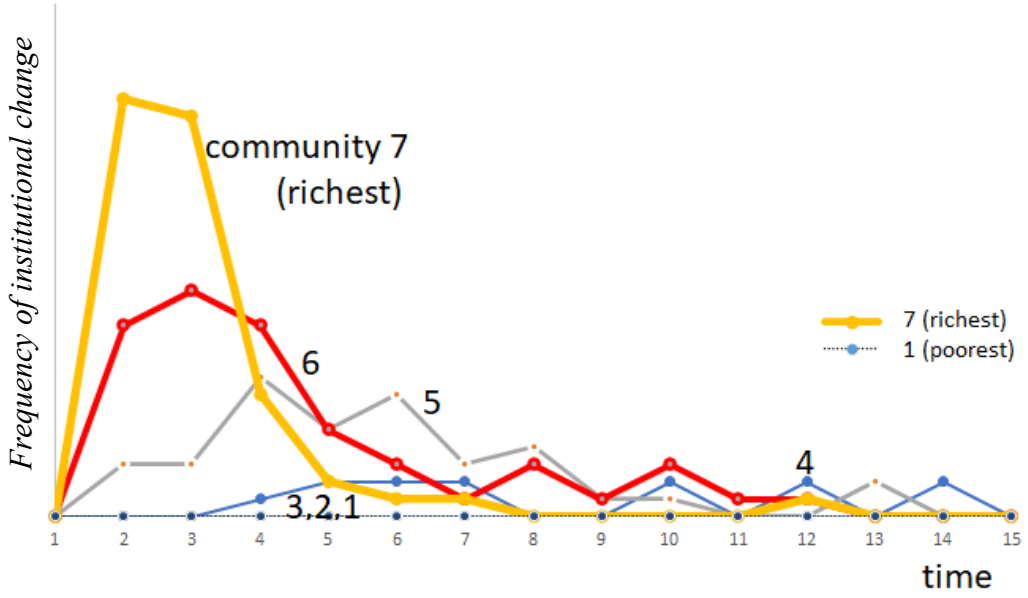
Table 1. Frequency of institutional changes by community

Community:	1 (poorest)	2	3	4	5	6	7(richest)
Frequency of institutional change:	0%	0%	0%	22%	62%	88%	98%

Notes: communities are ordered from 1 to 7 by increasing initial per-capita collective wealth. Elaborations are based on 60 runs.

A study at the community level suggests a similar pattern to the waves made by a stone thrown in a pond (Figure 4). This dynamic of institutional change at the level of the single community exhibits three characteristics. First, the timing of institutional changes follows a precise sequence according to the ranking of the communities in terms of per-capita collective wealth. Second, the peak of each wave is smaller as we move down the ranking. Third, the poorest communities experience no institutional change: in Figure 4, they appear as a flat line at zero.

Figure 4. Diffusion of institutional change from the richest community down.



Notes: Time on the horizontal axis (seven rounds per unit). 60 runs.

E) A higher inequality in terms of collective wealth across communities generates more institutional changes. In particular, the number of switches to patrilineal inheritance is positively correlated with the standard deviation in initial per-capita collective wealth across communities (rho=0.62). Although, in principle, the number of communities switching can range from 0 to 7, the result over 60 runs shows that there are only instances of 0, 1, 2, 3, or 4 communities switching to a patrilineal system (Table 1). For the runs with one institutional change, the standard deviation in initial per-capita collective wealth across communities is, on average, 0.44. This value monotonically increases in the number of institutional changes. For those runs with four institutional changes, it is 0.68.

6. Additional historical patterns of institutional change

In this section, we relate some of the model predictions with the empirical evidence. One model prediction is that only a subset of communities will adopt patrilineal inheritance. The historical pattern 3 is in line with such prediction (A).

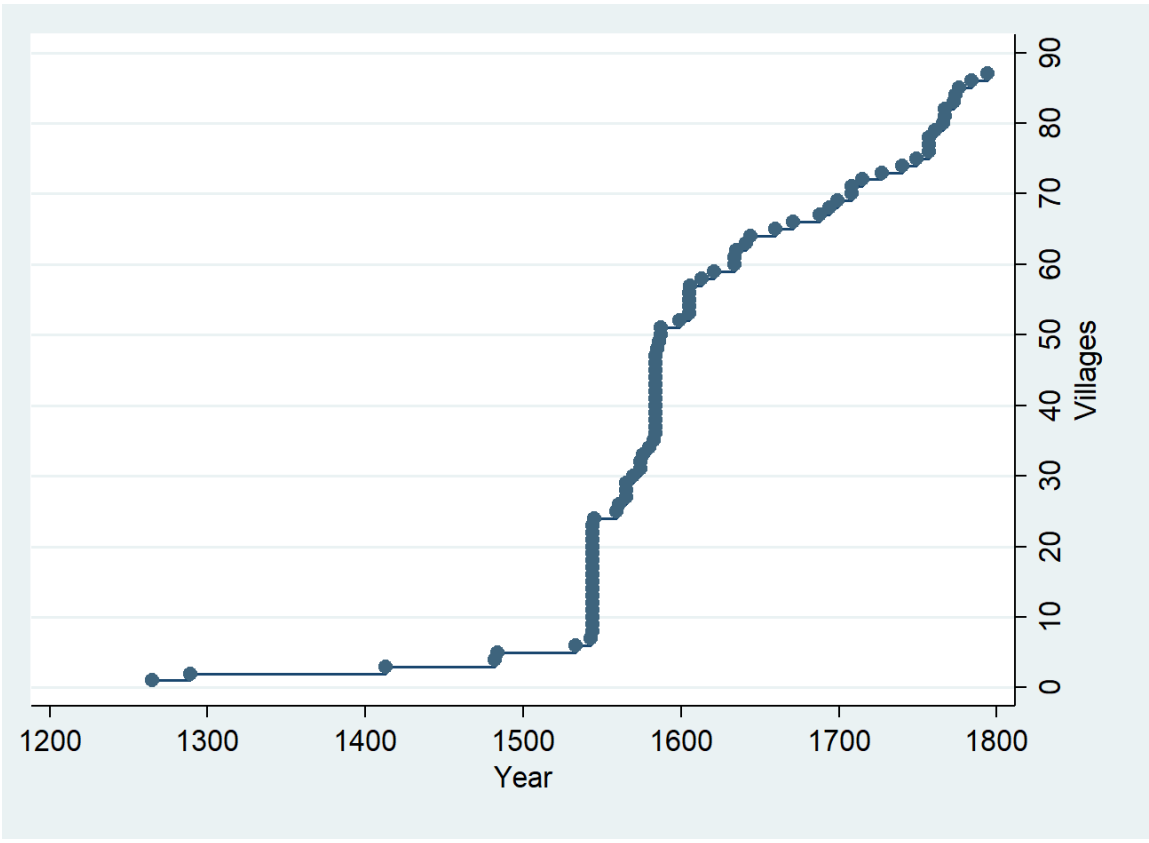
Historical pattern 3: No mention of inheritance in most communities. By the year of the Peasant war (1525), the share of Trentino territory that had formally introduced inheritance regulations over their commons amounted to about 2.8% of the regional surface. Formalized inheritance regulations became later more widespread, but even at the end of the period in the year 1800, it covered only 28.6% of the region. A similar pattern emerges when counting villages instead of the land surface. The vast majority of communities did not formally regulate inheritance on the commons. Out of 366 villages in Trentino, by the end of the period under scrutiny, only 23.8% did. To put this phenomenon into context, consider that by 1800, most villages had a charter (290), but only 29.2% mentioned inheritance rules. Charters were legal documents with a low level of complexity and dealt with issues in an unsystematic way, usually encoding only problematic aspects, especially those that had generated controversies in the past.

Notice that in most cases (87.4%), the formalization of inheritance regulations on the commons occurred years after a village adopted its first charter. Of these cases, half were included in later versions of charters, and another half was stated either in specific chapters added to an existing charter or in other legal documents. In the remaining instances, formalization of the inheritance system was concomitant with the adoption of the first charter in 6.9% of cases, or even before in 5.7% of cases. This evidence suggests that inheritance rules had a specific driver, distinct from the need for a

commons' general regulation. Charters were essentially tooled to promote coordination and cooperation among community members (Casari, 2007). Moreover, it suggests that the date of formalization was not primarily affected by the transaction costs associated with the change.

Historical pattern 4: Slow diffusion. The process of formalizing inheritance regulations on the commons unfolded over at least 529 years. The first formal mention of the inheritance system in a document dates to 1265, and the last one dates to 1794. To properly frame this process, we should first consider the social, economic, and demographic disruption of the 1348 plague. Population in Italy took more than a century to recover to the pre-plague level (Bellettini, 1987), although in Trentino, recovery may have been quicker (Cole and Wolf, 1974 reports for Trentino a population estimate of 83,373 in the year 1312 and 125,059 in 1427). Even when counting only from the restart of the diffusion process in 1484, when a major community adopted a patrilineal inheritance, we are considering 310 years. Over time, the pattern of diffusion roughly followed an S-shaped curve with a slow beginning in the first three centuries, an acceleration in the XVI century, and then a long tail until 1800 (Figure 5).

Figure 5. Cumulative number of villages formalizing the inheritance system on the commons.



Notes: a dot represents the year when a village first formalized its inheritance system on the commons.

Two discrepancies emerge between the empirical evidence and this model prediction. Toward the end of the six-century period, the historical rate of institutional changes picks up again, while the model predicts a convergence toward zero. We attribute the empirical evidence to a novel shock in the system, which was not in the model. The shock originates from an attempt by the central State authority to limit the degree of local self-determination, which prompts communities to re-write charters and re-calibrate governance rules on the commons in light of this top-down pressure. The other discrepancy concerns assumptions about the population. In the model, population and migration are the drivers of institutional change. While it is an assumption of the model that population at the district level is stationary, the historical record shows a more than doubling of the regional population over these six centuries, with alternating periods of population growth and decline. We already noted this within the historical pattern 4, and now will link it to what triggered institutional change.

Why does institutional change take off in the mid of the XVIth century? We conjecture that two main triggers played a role: population growth and increased geographical mobility (Figure 6). Beginning around the year 1430, we observe in the Center-North of Italy a long period of population growth (Malanima, 2002), which anticipates the surge in institutional change observed in Trentino (Figure 5). Endogenous growth in the community population reduced the per-capita amount of collective wealth. Consequently, for an insider, the marginal value of the common land rose. Likewise, the increase in mobility boosted the chances of an outsider marrying an insider. The impact of marrying an outsider was twofold. On the one hand, it increased the community size in addition to the endogenous population growth. On the other hand, it also introduced heterogeneity within the group of insiders. Although this could have been welcomed as it diversified the gene pool in small communities, it likely generated frictions in the collective decision-making process that characterized the management of the commons (Casari et al., 2019, Casari and Tagliapietra, 2018).[10]

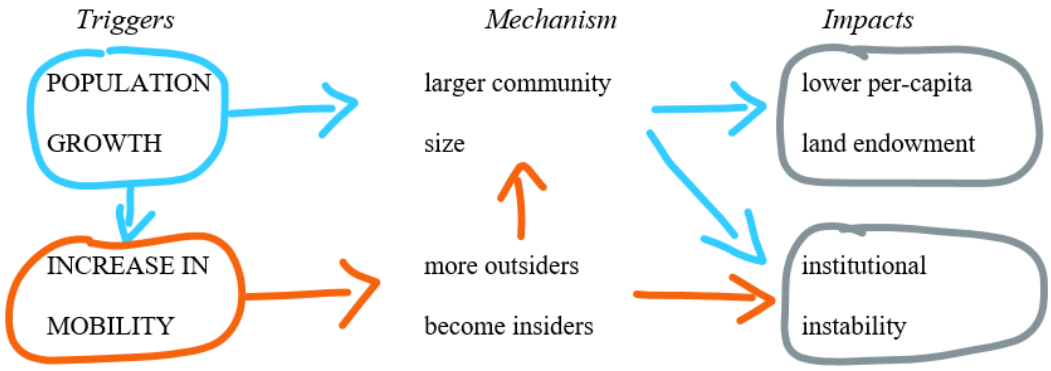
The model predicts that if relocation costs are too high, no institutional change occurs (C). In the model, relocation costs are set constant over time. In the field, though, they may have declined over time, especially in the XVth century, which would have increased mobility. The two triggers, population growth and increased mobility, were intertwined in a variety of ways. For instance, a larger population likely brought about an increase in internal mobility; the immigration increased community

[10] This situation is epitomized by the 1583 Charter of the Val di Fiemme community that complained about outsiders marrying local women who are blamed for "damaging" the common resources. "*...questa osservanza era molto dannosa et preiudiciale ad essa Communità, perché molte figliuole si maritavano in persone forestiere, quali si accasavano nella valle et facevano gran rovina nelli beni communi et spetialmente alli boschi.*" (Le consuetudini, Libro II, del civìl, Cap. 117) (Delugan and Visani, 1988).

size; and when a community was excessively large, institutional stability could suffer (Casari and Tagliapietra, 2018).

Casari and Lisciandra (2016) report a correlation between institutional change and population dynamics. The empirical evidence shows a slowdown in the rate of institutional change when the population declines. Moreover, the available historical evidence suggests starting in the mid-13th century and for the whole 14th century a substantial increase in the volume of exchanges of goods and services as well as people between the Trentino area and the surrounding regions (Varanini, 2004). We take this as indirect evidence of an increase also of internal migration. A local historian wrote: "The demographic increase and the intensification of immigration by outsiders, …, in the XVI century induced the introduction of more rigorous exclusion criteria" (Sartori Montecroce, 1891). In the following century, the region became an international crossroad with the Council of Trent, which took place in 1545-1563 to counterbalance the Reform movement.

Figure 6. Triggers of institutional change.

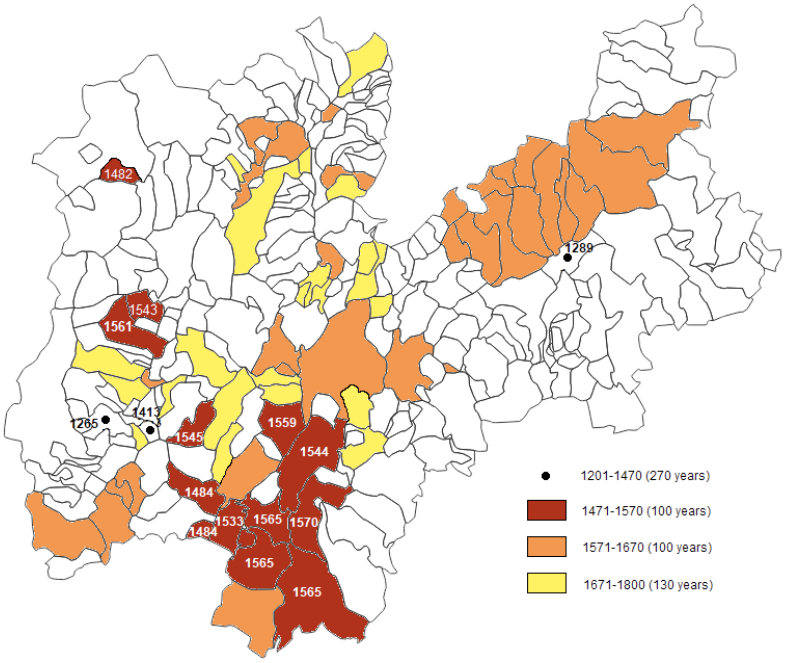


The model also predicts that the relatively richer communities in terms of per-capita common wealth would show higher rates of institutional change (D).

Historical pattern 5: institutional change and per-capita collective wealth. The empirical evidence provides some support for it. From the historical data, the communities with higher per capita value of collective land were more likely to have introduced formal inheritance rules. More precisely, a village with a per capita value of collective land higher by one standard deviation than the average village has higher chances to introduce inheritance regulations on the commons by 13 percent by the year 1800 (Casari and Lisciandra, 2016). This evidence supports the interpretation that those communities more endowed in per capita collective wealth acted to change their inheritance regulations as a protective measure.

There also exists empirical evidence about the diffusion of this institutional innovation by local contagion. This version of the model is not equipped to capture it because the model has no notion of neighboring communities, as (i) all communities are equally distant, and (ii) the relocation cost captures the loss of moving per se, independently of the destination. An extended version of the model, which includes distance as an explicit parameter, may have more predictive power.

Figure 7. Geographical diffusion of institutional change in Trentino.



Notes: 1265, 1289, and 1413 data points refer to a portion of a village territory.

Historical pattern 6: Diffusion by local contagion. Geographical distance played a role in the diffusion of institutional change. If we set aside the earliest movers, for about a century (1470-1570) institutional changes was mostly clustered in a relatively small and contiguous area (Figure 7). The first three villages to formalize the inheritance system on the commons were peculiar and in many ways atypical, as their regulations applied only to a portion of the village territory and often only to a subset of the individuals, rather than codifying inheritance for the whole community.[11] In the following century (1571-1670), the institutional change spread more, both locally and in more distant communities. By 1800, the Trentino map shows vast areas without any formalization of the inheritance

[11] Pieve Tesino in 1265 and Pradibondo in 1289 were *vicinie*, i.e., subgroups of community members who had exclusive access to a specific portion of land. Zuclo in 1413 is a forest regulation document for a specific mountain area. None of these documents had on them the approval of the Prince Bishop of Trent, which was instead required for charters.

system and clusters of adjacent communities with formal regulations. It was rare to find an isolated community with inheritance regulation.

Econometric evidence of diffusion by local contagion is presented in Casari and Lisciandra (2016) in a dynamic analysis over five-year intervals. Interestingly, the diffusion of charters' for the management of the commons in general did not exhibit local contagion (Casari, 2007).

7. Discussion and Conclusion

We provide a model that describes the progressive closure of more affluent societies to immigration to protect the wealth of insiders, and the following switch back to an open society. This can explain the historical path of institutional change in communities in the Italian Alps during six centuries. This section puts forward some general considerations on the implications of the model results, some of the model limitations, and possible extensions.

In the computational model, an egalitarian system tends to equalize per-capita collective wealth across communities because of migration flows. In contrast, a patrilineal system protects the community per-capita collective wealth by restraining migration through marriages. The model shows how institutional change happens in the richest communities, but never in all communities. When a community switches from an egalitarian to a patrilineal system, it restricts the set of available destinations for migrants and diverts potential immigrants to other communities. This process is characterized by path-dependency: the earlier decisions of some communities to change the inheritance system in favor of men sets in motion subsequent adjustments in other communities. Hence, institutional change spreads by contagion.[12] Left alone under decentralized decision-making, communities engaged in a progressive closure towards outsiders.[13]

In the computational model, decision making is decentralized: single individuals and single communities act in autonomy. This setting contrasts with the centralized institutional change put in place around 1800 when Napoleon restored an egalitarian inheritance system on the commons.

[12] In the model, the diffusion of institutional change operates in a different way than for instance in financial contagion. Consider the case of the credit crunch during the 2008 financial crisis. After some initial large bankruptcies, banks did not trust each other in the interbank lending market because of the uncertainty about the financial exposures of each financial institution. A domino effect is present in both situations, as the initial events set off a contagion of others, but the dynamic of the subsequent pressure differs in the two situations. In the Trentino case, the pressure is weakening over time while in a financial crisis it gets stronger.

[13] A matrilineal system would have also protected a community from the levelling effects of an egalitarian system. The effects, though, may or may not be identical to those of a patrilineal system because the version of the Gale-Shapley algorithm adopted in the computational model assumes that men take the initiative in finding a partner. If this assumption remains, the results of patrilineal and matrilineal inheritance may not come up symmetric. Another important qualification of the results is that the institutional choice in the model is binary. One could consider how the possibility of districts with a simultaneous presence of three types of inheritance systems (Egalitarian, Patrilineal, and Matrilineal) could impact the dynamic in a district. For a discussion about the reasons for the patrilineal system see for instance BenYishay et al. (2017) and Casari and Lisciandra (2016).

According to the computational model, when transitioning from an egalitarian to a patrilineal system is complete, the communities remain in a stable state. Nobody has an incentive to switch back to an egalitarian inheritance system. If a patrilineal community does it, this course of action will expose the community to a considerable reduction in per-capita collective wealth because individuals from other parts of the region would flock in and marry community members. The communities are effectively locked into a situation of women's discrimination and unable to move back to an all-egalitarian inheritance system.

This lock-in effect springs from the decentralized decision-making over inheritance systems. A shift from a patrilineal to an egalitarian system is particularly difficult when done unilaterally by a single community because all the migratory pressure would focus on that community. Instead, if all communities simultaneously revert to an egalitarian system, the short-time pressure on the single community would be lower, although, with decentralized decision-making, it would still not generate a new stable situation. Was an egalitarian system in any way optimal? Besides fairness considerations, an egalitarian system provides some insurance to individuals against shocks hitting communities asymmetrically, through the possibility to emigrate to another community. As pointed out by Casari and Lisciandra (2016), "From a long-run perspective, risk-averse individuals would prefer to live in a society without high costs of moving to other villages in case of exogenous shocks."

The way gender equality in property rights was re-established was through an act of the central state for the whole region. After the Napoleonic invasion, a modern, centralized state replaced the traditional political regime. Communities lost their autonomy of decision over the management of the commons and to customize property rights locally. This exogenous shock unlocked the situation and restored property rights for women.

In principle, inheritance about private land could follow rules that are independent from those about common land. The evidence for Trentino suggests that the two systems did actually diverge. Patrilineal inheritance on either private or common land generates a loss of bargaining power for women in the selection of a life partner and within the household. Yet, the focus of this paper on common property resources is an essential element. First, because the dynamic of institutional change can be very different depending on whether we deal with private or common land. While a change in inheritance on the commons can spread by contagion, this is not the case when referring to private land. Second, because the implications of this model of institutional change hold regardless of the inheritance systems adopted for private land. If communities have patrilineal inheritance on private land but egalitarian inheritance on common land, the model reasoning remains unchanged.

The model intentionally excludes any cultural component to the transition toward the patrilineal system. Institutions are likely to be shaped also by cultural aspects, and this case may not be an exception. We simply showed how far a purely incentive-driven explanation could lead us in explaining the historical patterns.

The computational model presents a variety of limitations. The model assumes a stationary population level to facilitate the interpretation of the basic results and highlights the mechanisms at play. This does not fit the historical data for these six centuries. A model with endogenous population growth could address this aspect. A critical parameter to consider for this exercise is whether fertility rates were the same in egalitarian and patrilineal communities. The inheritance system on the commons could affect the population of a community through at least two channels: one that influences migration patterns across communities and the other that alters incentives for internal population growth. About the latter channel, Casari et al. (2019) showed that egalitarian communities in Trentino had a higher fertility rate than patrilineal communities. In addition, while immigration has an immediate impact on community welfare, the impact of endogenous population growth is only visible in the long run. These elements would likely reinforce the results of the model.

The model assumes that the total value of the commons in a community is fixed, regardless of the population level. The value of the commons, though, in terms of stream of benefits for community members, depends on the ability to avoid the tragedy of the commons. However, we know that community size plays an essential role in sustaining cooperation in the management of the commons (Casari and Tagliapietra, 2018). This may have played an additional role in influencing the institutional change.

As we discuss in Section 6, removing the above limitations may shed light on the historical timing of when the all-egalitarian district became unstable and then the cascade of institutional changes began. Historically, the decades before 1480 seems to divide an age of stability from an age of instability in the egalitarian system.

A related point regards the advantages of the egalitarian system. The Trentino communities often shifted toward a patrilineal system gradually, by first introducing what we called a soft-patrilineal system where families with only daughters could transmit membership to one or more of them (Casari and Lisciandra, 2016). Moreover, they never transitioned to primogeniture, which would have ensured an even more rigorous incentive to limit community size. A possible factor was parents' desire to equally ensure all their children fair economic welfare and the possibility of having bargaining power in choosing a partner to marry.

One last limitation of the computational model is in the treatment of individual land. Ownership of individual land is part of individual attractiveness and it is classified as a mobile asset. We assume that the owner can sell the land in one community and buy land for an equivalent value in another community. At the margin, this reasoning can be a good approximation if many people migrate, this may not be the case. If the amount of individual land in a community is fixed (which is debatable at least for the earlier centuries), prices will adjust to demand. Prices will go down in communities of net emigration and go up in communities of net immigration. In a sense, for a land-owner the choice of moving from a poor to a rich community may be more costly than assumed in the model because one's attractiveness score will be different when staying or leaving. In particular, it is higher if the person marries an insider compared to moving to a richer community.

The purpose of the model is to provide a rigorous and simple representation of the driving forces behind the institutional change in Trentino. Below, we list some extensions that may provide a better fit for the field conditions. There is a tradeoff between making the model more complex and how much additional insights one may get. Undoubtedly, these extensions could constitute a robustness test of the results when read in conjunction with the baseline model. (*1*) The interaction within the district is currently global. Adding geographical or social distance between the communities will help to capture the historical pattern of local contagion. (*2*) Individual utility functions in the computational model are linear. A concave function is likely to provide a more accurate description of preferences. (*3*) The environment is currently deterministic. One can consider temporary or permanent random shocks to the value of collective wealth that hit communities asymmetrically. (*4*) In the model, the collective decision for institutional change is quite simple, but it has a large impact on the results. One could explore other rules, or build a political economy model of community decisions.

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