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Identity, Authority and Evolution of Order: the trajectory of dueling simulated

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Abstract

Borrowing from public choice literature, while aristocratic civil wars can be regarded as anarchy, and the monopoly of violence by the state as Leviathan, duel of honor is an orderly anarchy. The sudden or gradual withering of duel of honor as an institution marks the transition to the monopoly of violence by the state in Europe. In this paper, we endeavor to capture this transition by introducing a computational model where a simulated agent considers three sets of factors to make its dueling decision: 1) its own characteristics such as dueling skill; 2) its identity such as the reaction received from other members of its own social group; and finally 3) the reaction of the authority such as the possible punishment that could be inflicted by the state against dueler. These factors then interact through a dynamic utility function affected by both optimization and learning processes. The results of our agent-based computational model which are validated against the historical evidence from England, France, and Germany show that a complex, aggregative historical process may be consistently explained on the basis of rational choice of heterogeneous individual agents conditioned by their group identity and authority (organizational) influence.

Keywords: Agent-based Computational Economics, Conflict theory, Duel of honor, Identity Economics, Orderly anarchy.

JEL: C63, D02, D74, N43, P16

I. Introduction

In July 2012, the journal of *Public Choice* published a manuscript by Richard Wallick on the potential advantages of applying agent-based modeling (ABM) in analyzing public choice systems where he also reviewed the significant legacy of Gordon Tullock as "one of the founders" of using ABM in social sciences. Wallick insightfully discusses how over his fruitful research career, Tullock "never loses sight of the fact that agent behavior is the key to understanding any problem in the public choice" (Wallick, 2012, 236).

In this paper, following the approach that Tullock and many other scholars have practiced over the last few decades, we present a model which to our knowledge for the first time, borrowing Schelling's (1978) terms, associates individual economic "micro-motives" of duel of honor with the socio-political patterns of dueling "macro-behavior" – presented as duration and intensity of practicing dueling in a simulated environment.

Duel of honor is one of the best indicators of political transition from the older feudalism of fragmented political power to a stronger, centralizing monarchy that lasted much longer in France than in England, and longer in Germany than in France. This process corresponds to Hobbes's transition from anarchy to Leviathan. Borrowing from public choice literature, while aristocratic civil wars can be regarded as anarchy, and the monopoly of violence by the state as Leviathan, duel of honor is an 'orderly anarchy,'[1] because it entails extra legal or illegal strictly codified and regulated private conflict.

Duel of honor is "a fight between two or several individuals (but always equal numbers on either side), equally armed, for the purpose of proving either the truth of a disputed question or the valor, courage and honor of each combatant. The encounter must be decided or accepted jointly by both parties and must respect certain formal rules, be they tacit, oral or written, which will give it the weight of a legal proceeding, at least in the eyes of the two adversaries" (Billacois, 1990, 5). Dueling is thus a strictly *codified private* fight[2], negotiated and mediated by seconds. Duel of honor should be distinguished from both the *judicial* duel (trial by combat)[3] and dueling for chivalry

[1] For a detailed discussion of 'orderly anarchy', see Powell and Stringham (2009).
[2] Two treaties about the code of dueling were published in the 1590s (Stone, 1965, 245). Many codes of dueling were published since, including the *code duello* adopted at the Clonmel Summer Assizes, 1777; this contained 26 rules which were reprinted in Truman (1883, 48–53).
[3] The eminent French sociologist, Gabriel Tarde (1892, 30) distinguished *judicial* duel from German's *divinatory* duel, and defined judicial duel as a transitional form of dueling between German's divinatory duel and the duel of honor.

(Baldick, 1965, 11–32). The judicial duel was presided over by a public authority, i.e. the sovereign prince, whereas duel of honor was usually illegal[4] and privately organized.

The judicial duel can be traced back to A.D. 501, but the duel of honor was first described in Italy by 'doctors of duels' or 'professors of honor' from the 1360s (Giovanni da Legnano) until around 1560 (Muzio, Possevino). Their theories became known as chivalric science (*scienza cavalleresca*). Duels were popular in Italy, but the practice particularly flourished in France as a particular aristocratic social institution during the sixteenth and the seventeenth centuries and continued until the First World War. Dueling was introduced in England as a French fashion and persisted there until the first half of the nineteenth century. Germany also imported this French fashion, where it experienced a kind of golden age at the end of the nineteenth century (McAleer, 1994, 22–23). Dueling later spread to English colonies including the United States and Canada.

It should be noticed that duel of honor is a particular type of conflictual procedure that is not about appropriating a subject of predation such as a resource, wealth or any other kind of endowment as reported in Garfinkel and Skaperdas (2007). It is rather a private arrangement of violence management through self-organizing and self-regulating collective action of influential social groups such as aristocrats. Thus, duel of honor is an institution in itself during the transitional period between anarchy and order. The sudden or gradual withering of this institution marks the transition to the monopoly of violence by the state.

The analysis of this institution helps understand at least two major questions of current relevance that will be the focus of the present paper: 1) what is the role of identity investment of heterogeneous individual agents in shortening or lengthening the transition from anarchy to order? 2) To what extent, the emergence of an order is related to the place of army within the state and the ability of the state to enforce its rules precluding private arrangement of violence management? The historical importance of both issues notwithstanding, they are still relevant in emerging and developing countries traversing political transitions.

Understanding the duel of honor involves three levels: individuals (duelers), their identity (lower and higher nobility, officers, and later on middle-classes), and state organization particularly the army and the judicial or royal power. Empirical quantitative evidence on the emergence of dueling

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Leeson (2011) analyzes the judicial duel or 'trial by battle' within a Coasean paradigm in allocating contested property rights.

[4] Malta in Italy was one of the few places in which dueling was permitted by law in the sixteenth century. It was legally confined to the army in Sardinia; see Baldick (1965, 142, 144).

in Europe in the sixteenth century and its evolution all throughout the end of the nineteenth century in Europe is scarce. Although we have explored all the available statistics regarding the duel of honor in Europe, the paucity of data brings us to use other methods to illustrate this complex interaction of different variables. In our opinion, a simulated experience through ABM is a promising avenue.

As defined by Heckbert *et al.* (2010, p.40), agent-based modeling is "the computational study of systems of interacting autonomous entities, each with dynamic behavior and heterogeneous characteristics" which in economics is known as Agent-based Computational Economics (ACE): "the computational study of economies modeled as evolving systems of autonomous interacting agents" (Tesfatsion *et al.*, 2006, 264).

Within this approach, the economic model is considered to be a complex adaptive system, where macro-level phenomena are the emergent outcomes of micro-level decisions and interactions. In such models the computer acts as a simulator (Holland 1992) and the 'agent' is a set of features and functions that can represent different entities, ranging from an individual to a community, an organization, or even a physical object (LeBaron and Tesfatsion, 2008). To date, ABM models have been used to address the complexities involved in various social and economic models such as economic growth and business cycles (Dosi *et al.*, 2009 and Dosi *et al.*, 2010), civil violence and conflict (Epstien, 2002, Hassani-Mahmooei and Parris, 2013) and consumer behavior (Kirman and Vriend, 2001).

As Wallick (2012, p.224) argues and we present in this paper, ABM provides us with two main features, namely: "support for arbitrarily heterogeneous actors" and "support for adaptive behavior". ABM enables us to study how interactions at the individual level, based on heterogeneous features, result in shifts from one equilibrium state to another, allowing us to trace the dynamics back to their original causes at the micro level. As our model also deals substantially with "heterogeneity", "network effects", and "emergence", ABM seems to be an adequate approach for modeling gradual changes as well as punctuated equilibriums, and the impacts of individual decisions as well as social multipliers.

In the next section, we first present a modeled theory of dueling in four steps. In every step, we add a new feature to our model trying to build and present a replication of dueling trajectory as observed in Europe. Then, in section three we validate the model against the historical evidence from England, France and Germany and finally our conclusions are presented in Section 4.

II. A Modeled Theory

In this section and over four steps, we introduce a theory regarding the potential factors that have affected the duration and lethality of dueling. Accordingly, we develop a model which can show the dynamics of a simulated environment based on the investigated factors. At each step, we verify how successful the model is in replicating the available historical evidence on dueling.

While some scholars have studied the pre-engagement decision of dueling (Kingston and Wright, 2010), in this paper we focus on how the dueling engagement decision is made in the presence of a conflictual situation between two agents. Borrowing upon Boulding (1962), our model assumes three main levels in decision-making, namely 1) the individual; 2) the group; and 3) the organization.

Step 1: An Individual

We start the model with *n* agents. Each agent, *i,* is connected to a network consisting of a group of agents, *Ni,* representing the social community with whom each agent is going to interact during the simulation. The network provides us with two things: first, the opportunity to implement an information-sharing framework closer to the real world experience that an agent might experiment; second, it ensures that agent's decision is affected not only by its own, but also by monitoring others' experiences. The size of the network for each agent is a random value uniformly distributed between 0 and a variable called *network-size*. Two sample network structures are presented in Figure 1.

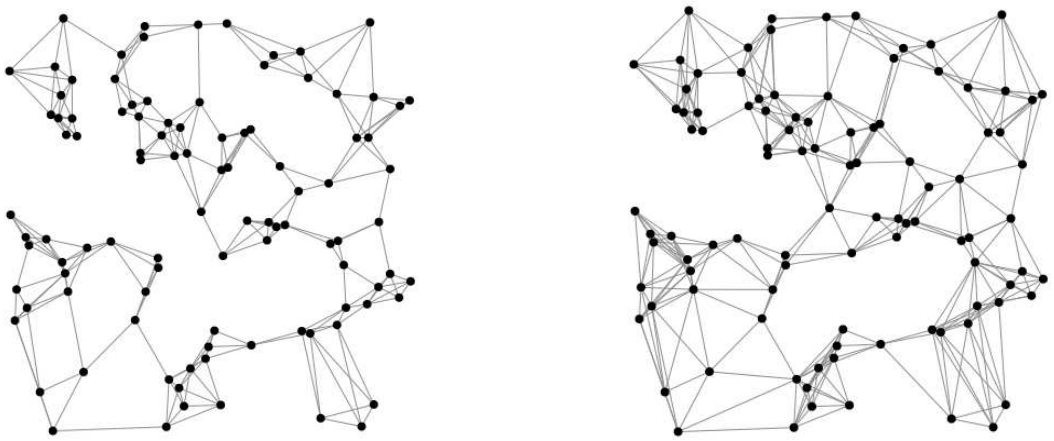

Figure 1: Two sample network structures with 200 agents and low (left) and high (right) linkage density.

When encountered with a conflict situation, each agent has different options to undertake. We call each of these options a *strategy*. The *strategy* of each agent is selected from a pool of strategies, represented by a three-bit vector such as [X_1 X_2 X_3]. Each bit can be 0 or 1 leading to a pool with eight different strategies. The first bit, X_1, is 1 if the agent is interested in taking the conflict to the court, X_2 is 1 if non-lethal dueling is preferred and X_3 is 1 if agent is interested in lethal dueling. For instance, if agent *i*'s strategy is [1 0 1], it means that when there is a conflict between agent *i* and another agent, he[5] prefers that conflict to be taken to the court or settled in a lethal duel.

Lethal and non-lethal duels are separated since as the historical evidence indicates, while pistol duels could only be terminated by death or by the exchange of agreed-upon number of shots, sword duel (either by épée or sabre) could be stopped when an injury produced a flow of blood[6]. In Europe, the sabre was more practiced by army officers and required a certain level of skill, whereas épée was more accessible to commoners (Jeanneney, 2004, p. 35). That is why the épée, which was probably the least favored of the three sanctioned weapons in the period before 1848, rose to prominence as the proper weapon for settling disputes of honor in the Third Republic (Guillet, 2008, p. 202; Reddy, 1997, p. 257). Table 1 summarizes the percentage of using each of the three major dueling weapons during the 1880s to provide an example regarding the application of each of the instruments.

Table 1: Duel's instruments in 1880s in France

Epée	Sabre	Pistol*
89%	1%	10%

Source: the data are based on Nye (1993, 186). All the pistol duels were not murderous, particularly because they were often fought at a greater and safer distance during this period.

The list of all potential options in the strategy pool is presented in Table 2. Later in this section it is discussed why this framework is chosen for presenting the strategy. Along with his *strategies*, each agent has also a variable called *best-strategy* which keeps record of the strategy which has led to the highest utility over the simulation. This means that our agent does not have an infinite memory,

[5] The duelers were generally male, since it was banned to women in all European countries. However, female duels occurred occasionally (Frevert, 1991, 287). Tarde (1892, 42) documents such duels as an exotic phenomenon.

[6] The choice of pistol versus épée was not only a technical matter, but also a philosophical issue on which two different schools opposed. One recommended pistol, since its outcome depended on mere 'luck'; and the other, épée, because of its insistence on 'bravery' (Jeanneney, 2004, pp. 34-39). Guy de Maupassant who considered the duel as "a stupid necessity imposed by human foolishness" argued that only pistol duel is the consistent type of dueling (1883, pp. v-viii). German gentlemen had their lethal pistol barrier duel and German student dueling involved rapiers or, in more serious cases, sabres and padding that produced facial scars (Frevert, 1991, p. 277).

since it can only remember the last best strategy it has experienced and replace it with a new strategy, if it leads to a higher level of utility.

Table 2: List of strategies in the strategy pool and their symbols

Strategy	Symbol	Interpretation
[0 0 0]	I	Agent takes no action and ignores the conflict in any case
[1 0 0]	C	Agent prefers to take the conflict to court
[0 1 0]	N	Agent prefers to do nonlethal dueling
[0 0 1]	L	Agent prefers to do lethal dueling
[1 1 0]	CN	Agent chooses between going to court or nonlethal dueling, but excludes lethal dueling.
[0 1 1]	LN	Agent chooses between lethal or nonlethal dueling, but excludes going to court.
[1 0 1]	CL	Agent chooses between going to court and doing lethal dueling, but excludes nonlethal dueling.
[1 1 1]	CNL	Agent is indifferent between the strategies.

I: Ignore, C: Court, N: Nonlethal, L: Lethal.

Each agent has a variable called *skill* indicating his expertise in dueling. Agent's *skill* is not fixed over the simulation time. When an agent engages in a duel and wins, his *skill* increases with a diminishing rate as presented in Equation 1, where skill of agent i at time t ($skill_{it}$) is a function of his initial skill ($skill_{i0}$) and number of his duel wins so far (W_{it}).

$$skill_{it} = skill_{i0} + \sqrt{W_{it}} \qquad (1)$$

Although different weapons have been used for dueling over the studied period and across the considered countries, for simplicity we consider that skill represents agent's average skill in using all the possible instruments whether the duel is lethal or nonlethal.

The unit of time is a 'tick', which designates a time frame in which the probability of each of the simulation functions to be executed is more than zero. To provide a sense of real world, we consider each tick to represent the duration of one week. The model starts with tick = 1 and runs for 100 years, so the total simulation is 5200 ticks[7] long.

Over the simulation agents reproduce with a fixed rate, r. The initial population, n, is 200 agents, which grows by 100% over the simulation time following the population growth between 1800 (203 million) and 1900 (408 million) in Europe (United Nations, 2008) which pertains to the three main case studies we will introduce later.

[7] For simplicity we consider each year to have exactly 52 weeks.

When the model initializes, at every tick, there is a probability of conflict, $P_{conflict}$, that an agent is involved in a conflict. $P_{conflict}$ is between zero and 1 and is similar for all the agents. For every tick, each agent can engage into conflict with any, but only one, other agent in the environment. When two agents are involved in a conflict, and considering that each of them has one of the eight possible discussed strategies, there exist 64 possible outcomes as presented in Table 3.

Table 3: Strategy combination and the final outcome

		Agent 2							
		I	**C**	**N**	**L**	**CN**	**LN**	**CL**	**CNL**
Agent 1	**I**	W	W	W	W	W	W	W	W
	C	W	C	W	W	C	W	C	C
	N	W	W	N	U	N	N	U	N
	L	W	W	U	L	U	L	L	L
	CN	W	C	N	U	CN	N	CU	CN
	LN	W	W	N	L	N	U	L	U
	CL	W	C	U	L	CU	L	CL	CL
	CNL	W	C	N	L	CN	U	CL	CU

W: Withdraw, I: Ignore, C: Court, L: Lethal, N: Non-lethal, U: Undetermined

As can be seen, there are four outcome categories in the model. First, when at least one agent ignores the conflict (I), no further action will be taken by the agents and they will both withdraw. Second, if no common strategy is shared between the agents, for example when one wants to go to court and the other prefers lethal dueling, again both parties ignore the conflict. Third, when both agents have similar strategies (e.g. C and C), or there is only one common letter in their strategies (e.g. CNL and C), then that common action will be adopted by both agents. Finally, if there is more than one common strategy (e.g. CL vs. CNL or CNL vs. CNL), the final outcome will be chosen randomly with an equal probability given to each possible outcome.

At the end of this process, the agents agree on how they want the conflict to be settled with four possible outcomes: 1) ignore, 2) court, 3) non-lethal duel, and 4) lethal duel. If the agents decide to withdraw, no further actions will be undertaken. If they decide to go to court, it is assumed that one of them will win and the other one loses with each having 50% chance to win. If two agents decide to duel (lethal or non-lethal), the outcome is determined by using a Tullock (1980) contest success

function (CSF)[8] where the probability of agent *i* winning agent *j*, $P_i(W_j)$ is determined through a function presented in Equation 2. In our model *m* is considered to be 1.

$$P_{it}(W_j) = \frac{{skill_{it}}^m}{{skill_{it}}^m + {skill_{jt}}^m} \quad (2)$$

When the winner is identified, the utility of winning or losing a duel will follow Table 4. According to the table, in a lethal duel while the winner wins all, the loser loses his life presented by using -∞. However, in the non-lethal dueling, the outcomes are less uncertain. Here, *Random*, is a function that returns a random real number between 0 and γ, so that in the nonlethal case the loser loses a random amount between 0 and –γ (due to a nonfatal injury). As -∞ may not be accommodated in later mathematical analysis, when the model is implemented, it is replaced with a large negative but finite number equal to the average of *network-size*. This implies that if an agent dies in a duel, on average, he would only make one level of his network to change their decision in the next round. At the end of this stage, each agent gains a utility based on his own and his opponent's decision and action. Since agents know the utility they derive from their actions, they undertake two more steps.

Table 4: Utility for each of the potential conflictual actions of an agent

Action	Utility for Winner	Utility for Loser
Court	1	0
Lethal Duel	1	-∞
Non-Lethal Duel	1	- Random (γ)

Firstly, each agent shares his findings with the other agents in his network. In this process, each agent *i*, who has a strategy such as $strategy_i$, will measure the average utility of his network members who have chosen the same strategy in their last conflict situation[9]. Through this process, agents calibrate their perception regarding the likely utility that can be gained from adopting that strategy. Secondly, agents apply a learning module to improve their decision based on their own gained utility. The learning process is captured by using a genetic framework. As it was discussed earlier, agent's strategy is presented as [X_1 X_2 X_3]. The implemented framework has one mutation

[8] Hirshleifer (1989) distinguished two types of contest success functions, namely ratio versus difference models of relative success. Skaperdas (1996) axiomatized the additive CSF employed in most contests as well as two frequently used functional forms of this function. Clark and Riis (1998) extended the axiomatization of Skaperdas. Kooreman and Schoonbeek (1997) provide an alternative set of axioms leading to a modified version of the Tullock CSF regarding the asymmetry between players. For an analysis of three classes of CSF and their relevance in different types of contests see, Konrad (2009, chapter 2).

[9] It should be noted that due to the lack of historical evidence, instead of implementing a learning algorithm, we have only enabled the agents to share information with agents who have chosen a similar strategy pertaining to the fact that agents communicate with each other.

and one crossover operator. Over the simulation time, the agents randomly change bits of their strategy by mutating a randomly-selected bit in their strategy from 0 to 1 or vice versa in an attempt to experience the other available strategies in the pool and shift to a strategy with higher utility, if such a strategy exists. At the same time, they keep record of the strategy with the highest utility[10] (*best-strategy*) and do a crossover between their current strategy and the best, to ensure that they are optimizing their actions constantly by learning from their past experiences[11].

The model is implemented using NetLogo 5.0.2 (Wilensky, 1999) that has been widely used and suggested for agent-based modeling in social sciences[12]. Considering the above-mentioned rules and conditions discussed for Step 1, Figure 1 presents the duration of dueling era under 10 individual single model runs, each representing a sample randomly taken from 100 simulations. The trends illustrate the sum of both lethal and non-lethal dueling.

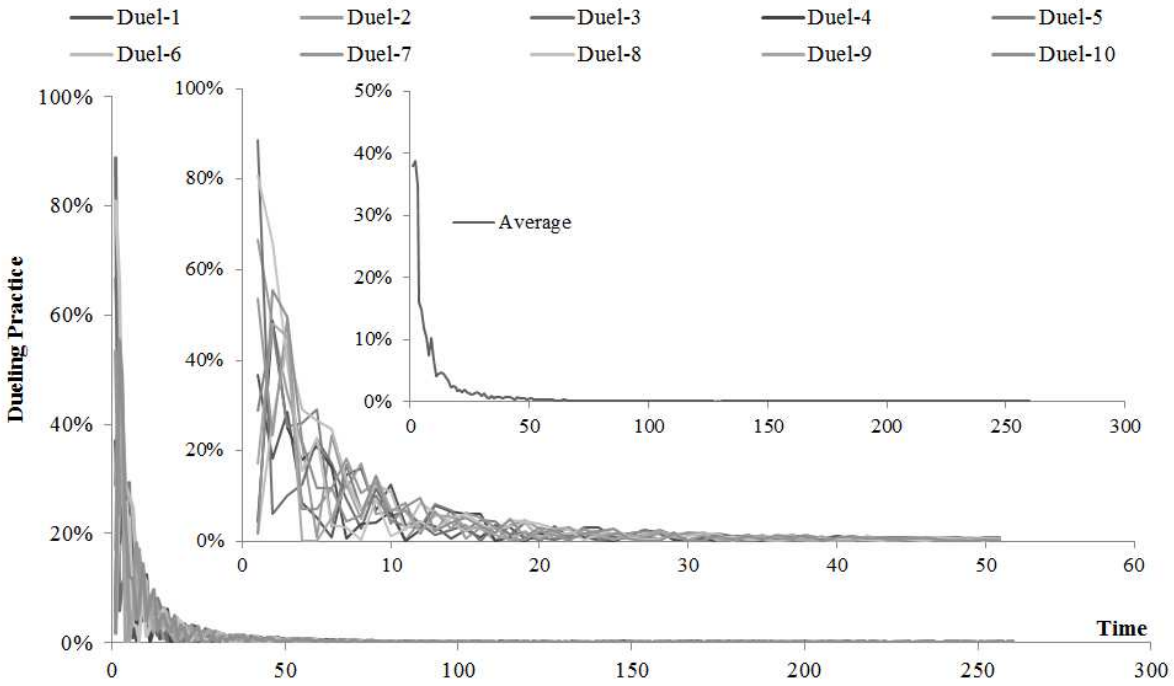

Figure 2: Dueling when only individual is taken into account. The figure is resulted from 1000 simulations, each line randomly representing one out of 100 runs. The largest graph shows the changes in dueling over the shortened time period of 260 (5% of total duration). As the figure is not very clear in presenting the dynamics of runs, in the middle graph the time scale has changed to 52 ticks (1% of the total simulation). Finally the smallest (top) graph, presents the average trends for the presented simulations.

[10] Agents do not record all the utility values derived from each strategy but they only keep record of the strategy with the highest utility. This means that they do not need an infinite memory or the ability to remember the maximum utility for each possible strategy. They simply need to keep the best strategy, represented by a [X1 X2 X3] format.
[11] Further detail and examples on these two processes are provided in the supplementary material.
[12] The pseudo code of the simulation program is freely available to interested scholars.

As Figure 2 shows, if the agents only take into account their gained utilities and even consider the experiences of their network members and learn through the model, the dueling would not survive for a long time. According to the model results, the Step 1 model will settle down on equilibrium where less than 1% of the agents will duel, and more than 80% will choose going to court. The model will not produce a zero-dueling environment since the mutation operator will keep activating the dueling bits and the probability of having two duelers encounter will be very small but not zero.

The average trend can be well estimated using a power model with a formula such as $y = \rho x^{\gamma}$ representing the sudden fall in the dueling practice. This fall can be mainly due to the combined individual learning process and information-sharing through the network that leads agents not to partake in a low-utility activity for a long time.

Step 2: Adding Identity

As it was shown in Step 1, it is not possible to use a simple utility model, even when enriched with learning and networking, to describe the appearance and disappearance of dueling in our simulated environment. So, how can the economist's rational choice theoretical framework handle the preference of individuals for dueling and its long persistence in various countries when considered as an emerging public choice issue?

It should not be forgotten that in the heydays of dueling, choosing dueling meant to answer the existential question of 'to be or not to be': a choice that mainly belonged to the aristocracy (and not to commoners) who behaved in compliance with the code of honor.

Obviously, the dueling decision is not like the usual economic choice of apple versus orange, but it is rather a choice dependent on the agent's identity. By identity, we mean the social categories to which an individual belongs as introduced by Akerlof and Kranton (2000, 2010).

These categories are associated with particular socially determined 'self-images' that include an ensemble of 'prescriptions' or behavioral rules to which an individual complies in accordance with its attachment to these categories. Accordingly, the norms of how to behave depend on people's positions within their social context. The identity economics thus extends the utility function by adding the agent's identity to the individual's preferences or tastes. But is there any historical evidence indicating the role of identity in dueling decision?

During the sixteenth and seventeenth centuries, Europe underwent a period of intense social, political, and religious tension and conflict. The aristocracy, the old ruling class, was in crisis and disintegrating into its various strata. It needed something to unite its ranks and restore cohesion. In other words, the collective action of the aristocracy needed a mechanism to shun free-riding and strategic behavior among its individual members. Dueling and its code of honor provided a social glue to unite lower and upper aristocracy in this transitional period. According to Demeter, the duel "strengthened their sense of belonging to a single privileged class" (1965, 119). Borrowing some terminology from identity economics (Akerlof and Kranton, 2010), the duel of honor provided identity, purity, and distinction to the aristocracy as the legitimate heir of the nobility of the sword from feudal times. It gave the entire class a military character and encouraged its patronage of new mass armies, while the new parliament and Courts enabled the nascent bourgeoisie and lawyers to have an increasingly strong influence.

Both upper and lower aristocracy benefited from dueling. By claiming the right to duel, the high nobility was symbolically showing that it had not surrendered its independent spirit to the monarchy. Dueling only appeared when the nobility was the "principal nerve of our state" (Billacois, 1990, 98), and "when the monarchial model blurs, when the model of a deliberating assembly, a parliament in the most etymological sense of the word, takes over" (Ibid, 30).

Lower aristocracy benefited from dueling for another reason. The practice was most common among minor country gentry or squires, "who hunt in the day, get drunk in the evening, and fight the next morning" (Young, 1925, 205). The enjoyment factor cannot be discounted, as the lives of country gentry tended to be monotonous,[13] but the major advantage of dueling was its leveling effect: "The duel was the sign and seal of a mystic equality between higher and lower, a fraternal bond uniting the whole multifarious class. It was, in short, a leveler, even though in practice a peer would oftenest be embroiled with one of his own kind, a squire with another of the squires (…) A duke ought to accept a challenge from a simple gentleman, Selden argued, because by treating him improperly the duke brought himself to the same level" (Kiernan, 1988, 52).

Considering the available evidence on the role of identity in how micro-economic decisions will lead to a macro-level public choice dueling phenomenon and following Boulding (1962) framework, a new level is added to the model called *group (G)*. Each agent now belongs to a group of: 1) the aristocrats (*A*); 2) the middle class (*M*); 3) and the commoners (*C*).

[13] Checkov (1921, 30) referred to this 'fun factor': "When there is no war, they are bored".

To accommodate the identity module in the model, four variables are added to the model. Three variables control the proportion of agents who belong to each of these three groups, P_A, P_M and P_C, standing respectively for aristocrats, middle-class and commoners, where $P_A + P_M + P_C = 1$. Then, aristocrats have a variable, *aristo-level,* representing their level of aristocracy, which is set to zero for commoners and middle-class and distributed normally with a mean of 1 and a flexible standard deviation, called *sd*, between 0 and 0.25[14] for aristocrats. Higher values of standard deviation indicate wider social differences between the aristocrats themselves and thus less unity among them. Middle-class agents are separated from the commoners by a Boolean variable called *midclass?* which is *True* for middle-class agents and *False* for commoners.

Some of already-defined variables in Step 1 are also updated. Firstly, following the historical evidence (Nye, 1993; Jeanneney, 2004), we expect the average *skill* to be higher for aristocrats than middle-class and commoners and so if A_i represents agent i and G represents the identity groups[15], we have:

$$\langle skill_i | A_i \in (G_M \cup G_C) \rangle < \langle skill_i | A_i \in G_A \rangle \quad (3)$$

Secondly, for each agent, the network is formed so that the majority of its members are from the similar group and fewer members are from the agents who belong to other groups. For instance, if agent i is an aristocrat, then majority of its network members will be aristocrats and so from G_A and smaller portion will belong to G_M and G_C. Here, the probability of agent j being a member of agent i's social network if agent i belongs to G_X is shown in Equation 1, where $G_{\bar{X}}$ presents the agents belonging to a different group. In such a setting, if $p\left(A_j \in N_i | \, A_j \in G_X\right)$ is equal to ρ, then $p\left(A_j \in N_i | A_j \in G_{\bar{X}}\right)$ will be $1 - \rho$.

$$p\left(A_j \in N_i | \, A_j \in G_X\right) > p\left(A_j \in N_i | A_j \in G_{\bar{X}}\right) \qquad (4)$$

The decision process for the agents is similar to what was introduced in Tables 2 and 3. But how does adding identity affect the outcome table?

[14] The value is selected in a way to ensure that the *aristocracy-level* is always between 0 and 2 and for majority of the individuals it is located between 0.5 and 1.5.

[15] It should be noted that while we allow the agents to have different levels of dueling skills linked to their identity (and later authority), we do not allow the agents to make their dueling decisions based on the their own or their opponent's skill. While this assumption may be unrealistic, but it is consistent with the fact that the changes in the length of dueling era will only be associated with IO and IS, rather than the changes in the skill.

According to Akerlof and Kranton (2000, p.728), if an agent belonging to an identity group takes an action which is not his group's activity, it would lose its identity which then leads to "a reduction in utility of I_s, where the subscript *s* stands for self" and other members of that group will also experience "a loss in utility I_o, where the subscript *o* denotes other". In this paper, we follow the same pattern. The updated values of outcome are presented in Table 5. As can be seen, two major changes are introduced in comparison with Step 1. First, now for every action taken by agents, IS_i and IO_i provide the identity component of the utility. Second, *sd* ensures that if aristocrats duel, then the advantages of their action will appear in their utility function. Coefficients, α_1, α_2 and α_3 are used to calibrate the impacts of each factor on the utility.

Table 5: Utility for each of the potential conflictual actions of an agent

Action	**Utility for Winner**	**Utility for Loser**
Court	$1 + \alpha_1.IS_i + \alpha_2.IO_i$	$0 + \alpha_1.IS_i + \alpha_2.IO_i$
Lethal Duel	$1 + \alpha_1.IS_i + \alpha_2.IO_i + \alpha_3\, sd$	$-\infty + \alpha_1.IS_i + \alpha_2.IO_i + \alpha_3\, sd$
Non-Lethal Duel	$1 + \alpha_1.IS_i + \alpha_2.IO_i + \alpha_3\, sd$	$-\, Random\ (1) + \alpha_1.IS_i + \alpha_2.IO_i + \alpha_3\, sd$

In the model, IS_i will be a randomly distributed number between 0 and 1, if the agent chooses an action in line with its group (duel for aristocrats and court for non-aristocrats) and between -1 and 0, if the agent's activity does not match with his identity (duel for non-aristocrats and court for aristocrats). As presented in Equation 5, when agent *i* takes action a_i at time *t*, $IO_i|a_{it}$ is measured by dividing the number of agents in his network who have adopted the same action by the total number of his related agents. IO_i which is between 0 and 1, indirectly provides us with a value for how the decision of one agent who undertakes a specific action, may affect the utility gained by other agents considering the action they have taken.

$$IO_i|a_{it} = \frac{\#\{A_j : A_j \in N_j \ \vee a_{it} = a_{jt}\}}{\#\{A_j : A_i \in N_i\}} \qquad (5)$$

The results of the model under Step 2 configuration are presented in Figure 3. As the figure shows, compared to Step 1, the dueling persists much longer in the model since the identity component incentivizes the aristocrats to duel more. Also, while minor changes in *sd* may not affect the duration of dueling period, the higher differences and hence the larger values of *sd* motivates more agents, specifically aristocrats, to consider dueling as an activity with high utility, at least for short time.

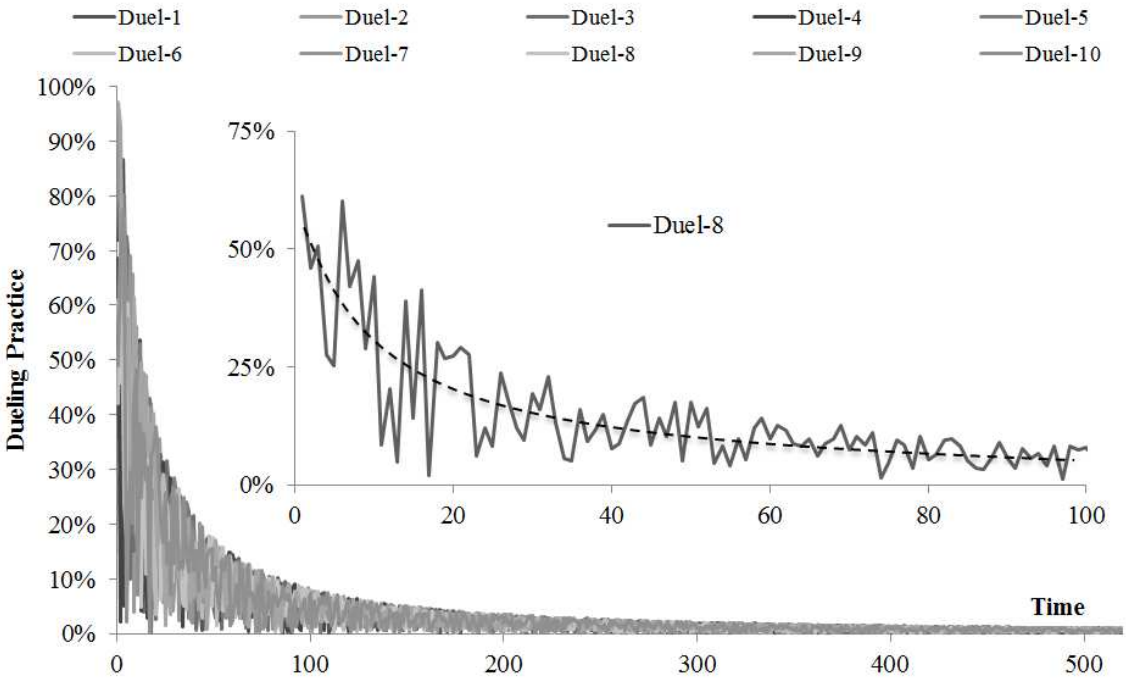

Figure 3: Dueling trend in an environment with identity. The outside figure shows the changes for 10 randomly-selected sample simulations out of 1000 runs and the smaller plot presents the trends for one randomly-selected simulation.

It should also be noted that the *IS*, *IO* and *sd* affectivity is highly related to the size of aristocracy group, so if aristocrats are not a large part of the whole simulated community, then the role of identity will be less significant.

Step 3: Adding Authority

As it was shown in the previous steps, while adding identity can help to some extent explain better the dueling phenomenon, we have not yet formulated an integral model to explore the dueling macro patterns. Then, what other evidence do we have which can be used to improve the model?

Historians have identified a link between weakened royal authority, civil war, and increased dueling. A strong and stable absolutist monarchy was more able to control dueling; the practice never took root in Spain, where the undisputed authority of the Catholic Church and the monarchy were united in banishing the duel. The Spanish aristocracy preferred bullfighting, as did commoners.[16]

[16] Billacois (1990, 38–39) explained how cultural factors affected the banishment of dueling in Spain. He argued that because honor was not a conquest but a family treasure, the duel could not re-establish a contested honor.

No exact and reliable statistics are available about numbers of duels and the number of people killed during duels, but French and English historians have collected many 'impressionistic statistics' (Billacois, 1990) about the emergence of dueling from the second half of the sixteenth century until the second half of the seventeenth century (Billacois, 1990; Cockburn, 1720; Kiernan, 1988; McAleer, 1994; Stone, 1965). Table 6 presents the trough periods and Table 7 presents the peak periods of dueling in France where dueling originated, based on these impressionistic statistics.

Table 6: Through periods of dueling in France

Trough period	Political situation
1618–1621	Resurgence of politico-religious conflict in Europe
1637–1649	France's open participation in the general European conflict

Table 7: Peak periods of dueling in France

Peak period	Political situation	Estimated number of deaths
1562–1598	Valois dynasty, crippled royal authority Chain of civil wars under religious pretext	8000*
1604–1607	Peace at home and abroad (Peace of Vervain) Disputed authority of Henry IV	6000 **
1611–1614	Minority of Louis XIII Meeting of the Estates General	25000***
1621–1626	Richelieu as a strong minister Military operations against the Protestant fraction	
1631–1633	Period of 'covert war,' France managing to delay its entry in the Thirty Years' War	
1649–1653	Following the Treaty of Westphalia and the partial re-establishment of peace abroad, civil wars collectively known as the Fronde (Catapult) of the princes	
	Total	39000

*Kiernan (1988, 75); Chesnais (1981, p. 104) estimated 7000 to 8000 deaths during the 1590s. **Stone (1965, 246) reported 6000 pardons by the king from 1600–1610; Tarde (1892, p. 43) estimated 7000 to 8000 deaths during the period 1589-1608. ***McAleer (1988, 18) estimated an average of 500 deaths annually from 1610–1660. Major Truman (1884, 22) estimated that the 'dreadful mania' took 20,000 lives, "more gentle blood than thirty years of civil war", and Chesnais (1981, pp. 103-104) reported 30000 deaths for the period 1610-1640. Considering the latter estimation, the total amounts to 43000 deaths.

An overview of the peak and trough periods reveals two findings. First, increased dueling is likely to be related to weakened royal authority, either because a monarch was too young (e.g., Louis XIII and Louis XIV), or because a monarch's right to rule was disputed (e.g., Henri III and Henri IV until 1598). Second, civil war stimulated dueling, whereas foreign war usually reduced the number of duels. The Thirty Years' War and the civil wars collectively known as the Fronde (catapult) encouraged dueling, especially because they undermined the authority of the sovereign. Foreign wars, if supported by public opinion, were a source of internal unity and effectively discouraged dueling among gentlemen. Similar results appear for Britain; duel of honor appeared in England around 1590 (Cockburn, 1720), and as in France, increased in prevalence until 1620. The rates of increase were similar in the two countries until 1600, when the rate in France increased faster than in England. The disparity was especially obvious from 1610–1620 (Billacois, 1990), and dueling rates declined sharply in England after 1620 (Stone, 1965). Dueling experienced a resurgence in England from 1644–1655,[17] before and during the English Civil War.

Historical evidence also show that the existence of a double standard or contradictory orders have also encouraged dueling, as for example, it has been widely observed in Germany, where social militarization happened causing the formation of a state within a state. From its inception in the last third of the sixteenth century, the duel was regarded as part of 'caste honor' (*standesehre*) among persons worthy of carrying swords (*satisfaktionsfähig*): aristocrats and officers, state officials, and students. Friedrich Wilhelm I of Prussia, the so-called 'Soldier-King' (1713–1740) adumbrated the fundamental link between dueling and militarism, and McAleer noted, "Duels were undertaken out of a feeling of co-responsibility for the collective reputation of Germany's social elite, out of a sort of tribal egotism, and not from a selfish amour proper" (1994, 35).

A double standard between 'military honor' and 'civilian honor' was instituted after the Prussian Law Code of 1794: a duel could only exist among officers and noblemen; armed clashes among other civilians, including the bourgeoisie, were handled by criminal law. Civilians were thus denied treatment under the dueling statutes. The conflict of principle between military and civil concepts of honor became strikingly public when Eritz Anneke, a Prussian second lieutenant, was dismissed from the army in 1846 based on his refusal to duel with a fellow officer. After its investigation, the military court of honor ruled out the possibility of cowardice and attributed Anneke's decision to his "communist and democratic notions" (McAleer, 1994, p. 26-35).

[17] Cromwell banned the duel in 1654. In the United States, the War of Independence stimulated the practice of dueling, but "the Civil War killed the duel" (Wells, 2001, 1838).

Taking into account the presented evidence and again following Boulding (1962), a new level is added to our model called "organization" represented by two major authorities, namely: state and military; the state runs the courts and the military is in charge of the army. If an individual follows the state laws, it is a "civilian", but if it belongs to the army and so follows both the state and military laws, it is called "officer". We believe that adding the authority to the model, to some extent addresses the concern stated by Buchanan and Tollison (1984, p. 13) and discussed by Wallick (2012, p.232) regarding the monolithic modeling of political entities such as government, separated from the agents, as in our model both organizations, state and army, are able to affect how the individuals make decisions.

Considering the introduced groups in Step 2 and these two organizations (i.e. state and army), six different identity-authority categories can be defined for as indicated in Table 8.

Table 8: Identity categories of the model in Step 3

	Authority	**Group**	**Category Title**	**Symbol**
1	State	Aristocrat	Aristocrat Civilian	C_{AC}
2		Middle-Class	Middle-Class Civilian	C_{MC}
3		Commoner	Commoner Civilian	C_{CC}
4	Military	Aristocrat	Aristocrat Officer	C_{AO}
5		Middle-Class	Middle-Class Officer	C_{MO}
6		Commoner	Commoner Officer	C_{CO}

The organization level features are accommodated in the model using three variables. First, *officers-to-civilians* shows how agents are distributed between the officers and civilians. The state is presented using a variable, P_{state}, ranging between 0 and 1, which shows the probability of a wrongdoing to be detected and punished by the state. The army's power is presented with a variable, $P_{military}$, again between 0 and 1, indicating the military's supremacy in the simulated society and its ability to punish the officers which do not respect the military rules.

The definition of skill initially introduced in Step 2 is now updated. Following the historical evidence, we expect the average *skill* to be higher for aristocrats than non-aristocrats, and higher for officers than civilians so

$$\langle skill_i | A_i \in (C_{MC} \cup C_{CC}) \rangle < \langle skill_i | A_i \in C_{AC} \rangle < \langle skill_i | A_i \in (C_{MO} \cup C_{CO}) \rangle < \langle skill_i | A_i \in C_{AO} \rangle \qquad (6)$$

Also, using the same symbols as used in Step 2, the network structure and connection probabilities are updated as presented in Equation 7.

$$p(A_j \in N_i |\, A_j \in C_{XY}) > p(A_j \in N_i | A_j \in (C_{\bar{X}Y} \cup C_{X\bar{Y}})) > p(A_j \in N_i | A_j \in C_{\bar{X}\bar{Y}}) \qquad (7)$$

According to Equation 7, the probability of agent *j* being a member of agent *i*'s social network if agent *i* belongs to C_{XY} can be shown as Equation 1, where $C_{\bar{X}Y}$ presents the agents from a similar group as A_i but following a different authority and $C_{X\bar{Y}}$ is representing the agents of similar authority as A_i but belonging to a different group. This time, if agent *i* is an aristocrat civilian, then majority of his social network members will be aristocrat civilians and so from C_{AC}, smaller proportion will belong to C_{MC}, C_{CC} and C_{AO} and the lowest proportion will come from C_{MO} and C_{CO}. In such a setting, if $p(A_j \in N_i |\, A_j \in C_{XY})$ is equal to ρ, then $p(A_j \in N_i | A_j \in (C_{\bar{X}Y} \cup C_{X\bar{Y}}))$ will be $n\rho$, and $p(A_j \in N_i | A_j \in C_{\bar{X}\bar{Y}})$ will be $m\rho$, where $\rho + n\rho + m\rho = 1$ and $n > m$ and $n + m > (1 - n - m)$. The values of ρ, n and m are set as initial conditions and vary across the experiments.

To include the authority responses to the action undertaken by agents, a new component is added to the outcome table called *AR*, representing the net responses received from the state and the military (Table 9). Here, $AR_i = \beta_1.Random\ (P_{state}) + \beta_2.Random\ (P_{military})$, where the values of β_1 and β_1 are dependent on the agent's category and action as presented in Table 10.

Table 9: Utility for each of the potential conflictual actions of an agent

Action	**Utility for Winner**
Court	$1 + \alpha_1.IS_i + \alpha_2.IO_i + \alpha_3.AR_i$
Lethal Duel	$1 + \alpha_1.IS_i + \alpha_2.IO_i + \alpha_3\, sd\ (Aristo) + \alpha_4.AR_i$
Non-Lethal Duel	$1 + \alpha_1.IS_i + \alpha_2.IO_i + \alpha_3\, sd\ (Aristo) + \alpha_4.AR_i$
Action	**Utility for Loser**
Court	$0 + \alpha_1.IS_i + \alpha_2.IO_i + \alpha_3.AR_i$
Lethal Duel	$-\infty + \alpha_1.IS_i + \alpha_2.IO_i + \alpha_3\, sd\ (Aristo) + \alpha_4.AR_i$
Non-Lethal Duel	$-\ Random\ (1) + \alpha_1.IS_i + \alpha_2.IO_i + \alpha_3\, sd\ (Aristo) + \alpha_4.AR_i$

Table 10: Utility coefficients

	Civilian	**Officer**
Duel (lethal or non-lethal)	$\beta_1 = -\tau$ $\beta_2 = 0$	$\beta_1 = -\tau$ $\beta_2 = \tau$
Court	$\beta_1 = 0$ $\beta_2 = 0$	$\beta_1 = 0$ $\beta_2 = -\tau$
$\tau > 0$		

What Table 9 provides us with is a set of simple rules: if a civilian or an officer duels, it will be punished by the government whereas if an officer goes to court it might be punished by the military. Considering the modules added during Step 3, we expect the model to have more complex processes since, for instance, for every agent, at any point in time, four different factors will affect the decision, including: 1) its personal learning, 2) the experience of its network members, 3) its identity, and finally 4) the reaction received from the authorities. These factors then will lead to a final decision made over time and across the agents.

The results of this step are summarized into two figures. Firstly, Figure 4 shows how overall dueling trend changes in the model across three sample simulations. The full line in the figure presents a case where state and military authorities almost neutralize each other and so the model response pattern is very similar to what was observed in Step 2. Then, as the military gains further authority power, the fall of dueling trend will be delayed (dashed and dotted lines), although the fixed dueling rate is not sustainable and the dueling finally disappears from the model over time. The main reason behind the delay and change in the pattern from the full to the other two lines is that as military gains more power dueling will be encouraged, both directly through the further pressure on officers and also indirectly due to increasing returns in investment identity. But this line of conflictual action will be undermined as more agents (especially aristocrats and officers) find the disadvantages of dueling and share it with others. Once this countertendency is triggered, it can even go to the point that the officers may also join the rest of agents in not adopting dueling strategy.

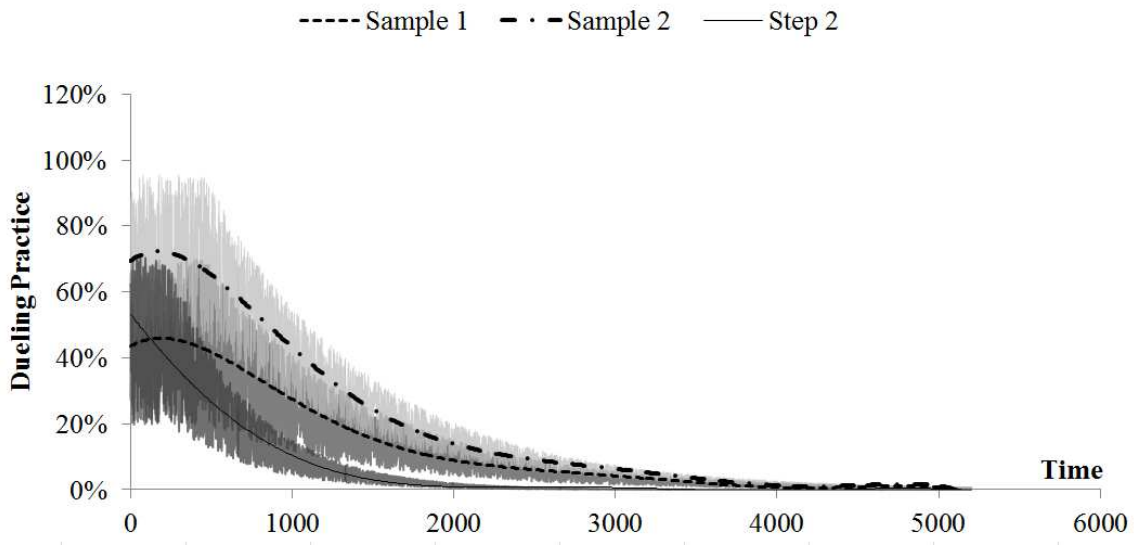

Figure 4: Results with Identity and Authority. The full line presents a case when the state and military authority levels almost neutralize each other and so the model response is similar to Step 2. The dashed and dotted line present cases with higher military authority levels.

As discussed earlier, we have separated the lethal and non-lethal dueling in this paper to see if it is possible to investigate their patterns individually. Now, the question is, out of what has been presented in Figure 4 (for example, Sample 1), how much does each lethal and non-lethal dueling contribute? Figure 5 decomposes the total dueling trend into lethal and non-lethal trends.

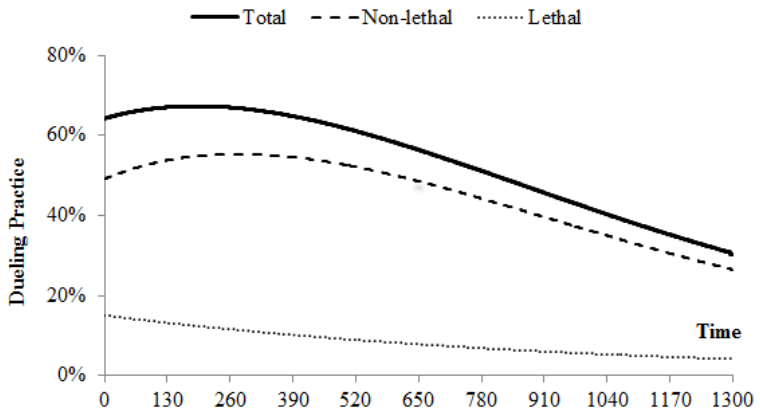

Figure 5: The trends of overall, lethal and non-lethal dueling for a sample model in Step 3.

As Figure 5 shows, while lethal dueling quickly disappears from the model, non-lethal dueling initially increases slightly. This can be due to the fact that some agent who witness how the lethal duelers lose their life, abandon lethal dueling and so the choice set shrinks from (Withdraw, Lethal, Non-lethal, Court) to (Withdraw, Non-lethal, Court).

Step 4: Embourgeoisement

In addition to the identity and authority components (discussed in Steps 2 and 3) that mainly affect the dueling decision among the aristocrats and officers; there are some historical evidence that dueling has been widely practiced by other social groups. In fact, the adoption of duel of honor by middle-classes has been named 'duel's embourgeoisement' by certain historians. This expression describes the process through which the 'limited access' of the aristocracy to a particular intangible asset, namely 'honor' was gradually converted into an 'open access' asset.

The term was initially coined by Weberian Frevert (1995)[18] to characterize the social nature of the duel of honor in Germany as a "middle-class" institution during the nineteenth century. The expression was also used by Nye (1993, p. 133) to describe the duel's status in nineteenth century France.

[18] Fervert's professorial dissertation on dueling was submitted for publication in 1989, published in Berlin in 1991 and translated in English by Anthony Williams in 1995. We refer to this English translation.

Frevert formulated the concept of duel's embourgeoisement against Marxist Kiernan who defended the thesis that the European duel in modern times was the last stronghold of aristocratic privileges against the invasion of mass industrialized society represented by an ascending middle class. He labeled dueling in the nineteenth century as "the phantom virtue of a bygone era" (Kiernan, 1988, p. 274). The focus of debate was about the social nature of dueling during its evolution in the nineteenth century, particularly in the second half of this century. Frevert questioned Kiernan's thesis by raising a few preliminary questions: who did duel with whom? Why? And to what end? Did the social strata, which supported dueling, change during the processes of social change? Which institutions, political parties or groups did support dueling and which ones did endeavor to restrict or forbid it? According to her, the central question of whether or not the duel of honor in the nineteenth century was merely a relic of the feudal era, or was a middle-class institution could not be answered without tackling these preliminary issues.

By reminding the large numbers of middle-class duelers and advocates of dueling such as Max Weber, Heinrich Simon, Heinrich Heine, and Ferdinand Lassalle, Frevert asks whether it can be assumed that there must have been strong tendencies on the part of the German middle class to incorporate dueling, originally the privilege of the aristocracy, into their own way of life. She doubts the validity of such an assumption in view of the proven anti-aristocratic stance adopted by these men: "it is at least doubtful whether it is possible to interpret this fact as a drive towards feudalization on the part of the middle class" (Frevert, 1995, p. 7).

Accordingly, she suggests the concept of "duel's *embourgeoisement*" instead of the "feudalization of German's bourgeoisie"[19]. Blackbourn (1991, p. 14) also advocates Frevert's thesis by acknowledging that it "shows that those German bourgeois who engaged in duels were not simply imitating aristocratic norms; the meaning of the duel for middle-class Germans was shaped by the place it occupied within a specifically bourgeois code of honor."

To embed the embourgeoisement in the model, a new variable is added, P_{imit}, which ranges between 0 and 1 indicating the likelihood of a non-aristocrat civilian to imitate the dueling behavior. The variable is accommodated in the model by updating the Table 10 values as now presented in Table 11. The changes will ensure that the civilians who duel will be less likely punished by the state.

[19] For a detailed analysis of the concept, see Kocka (1993).

Table 11: Changes in the utility coefficients to accommodate embourgeoisement

	Civilian	Officer
Duel (lethal or non-lethal)	$\beta_1 = P_{imit} - \tau$ $\beta_2 = 0$	$\beta_1 = -\tau$ $\beta_2 = 1$
Court	$\beta_1 = 0$ $\beta_2 = 0$	$\beta_1 = 0$ $\beta_2 = -\tau$

As changes in P_{imit} have significant impacts on the model responses, we test three different models to show how embourgeoisement may have long-term impacts on the likelihood of dueling.

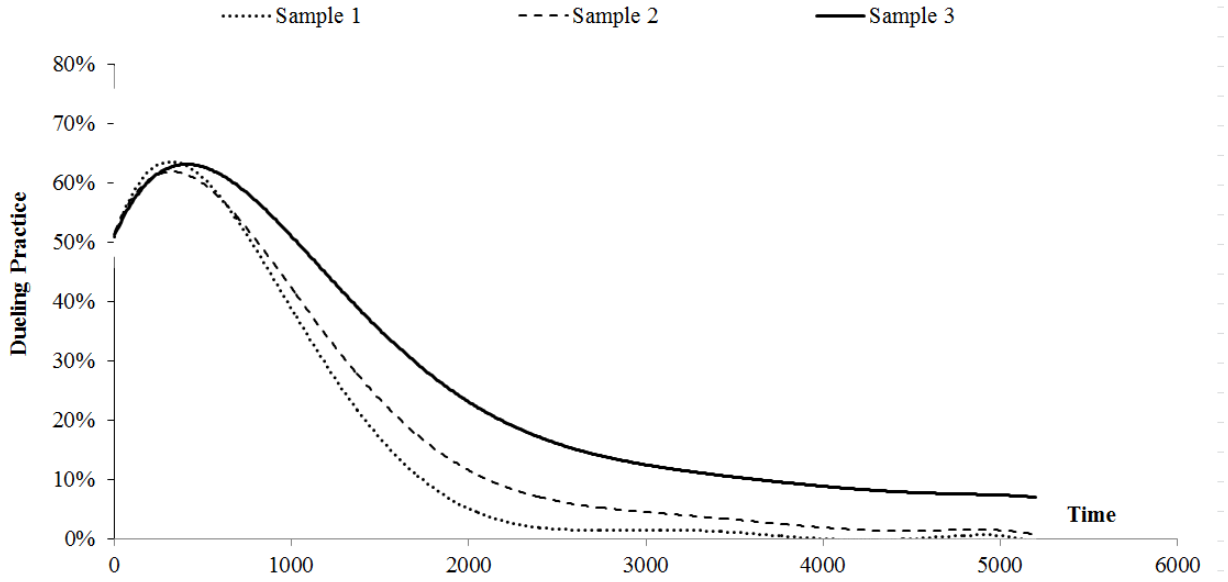

Figure 6: Dueling with low (Sample 1), medium (Sample 2) and high (Sample 3) levels of imitation probability

While the low or even moderate values of imitation do not affect the model substantially, as Sample 3 (full line) in Figure 6 shows, higher probability of imitation can make the dueling so popular that it could persist at a significant level in the model.

Model Validation

To validate our model's results, the model is run according to three specific scenarios derived from historical evidence. We then test whether our results match the historical trends. The cases are about the evolution of dueling in England, France and Germany.

English case: duel as undesired anarchy

In the early Tudor period, England had a dual military system: one quasi-feudal, composed of private aristocratic armies, and the other national, under the auspices of the Crown. The greatest achievement of the Tudors was shifting the structure of power from the Lords to the Crown and the Commons (Stone, 1965). This shift meant a royal monopoly of violence, both public and private. However, even during the reign of Elizabeth, this monopoly was far from complete and it needed to balance the rival factions to avoid the constant menace of aristocratic civil war. In this context, dueling was a better option than blood feuds, because it was more effective at regulating violence than the authority of the central government.

Dueling was thus an inevitable vice, because it was a leveler between upper and lower aristocracy. In the eyes of the Crown and nobility, it represented *undesired anarchy* and an infringement on the hierarchy of rank. The Crown was not alone in viewing dueling as undesired anarchy; the revolutionaries, Cromwell and his army, shared this view because dueling was against the law and the state. Since the adoption of the Magna Carta, collective action of the English ruling classes was instituted in the name of law. Magistrates and laws were central to English political thought from the Tudors onwards. The state was so distinct from the holders of power that Charles I could be tried and condemned for High Treason. The King was perceived (by himself and others) more as a magistrate than as the first among gentlemen, which explains why the revolutionaries justified their insurrection in the name of law. "In England, where Puritanism, capitalism, free enterprise and freedom of thought were important in a society which was otherwise very hierarchical, only isolated and more or less anti-social individuals felt the need to fight duels. The English revolutionaries were not duelers because duelers are rebels" (Billacois, 1990, 32).

The industrial revolution and the early rise of the industrial bourgeoisie in England gave this class a far more intransigent faith in its own ways and ideas than the previous capitalist class, mercantile or financial. Earlier versions of bourgeoisie found it natural to gravitate toward aristocracy, but later versions had a collective identity represented by the liberalism of the Manchester school[20] and the anti-corn law movement led by Cobden and Bright. Early industrialization saved the English industrial bourgeoisie from subsequent workers' movements because the bourgeoisie did not need to unite with the aristocracy against the working class (Lang, 1999, p. 26). At the heyday of industrial capitalism, the bourgeoisie allied with the working class against the landed aristocracy. In

[20] Andrew (1980) argues that the replacement of the 'code of honor' by a 'code of Christian commerce' in the middle of the nineteenth century was the outcome of a growing self-confidence and self-awareness of the English middle classes.

England, the bourgeoisie could only get its real representative, Bright, into the government by an extension of the franchise (Acemoglu and Robinson, 2005, pp. 2-5). Parallel with its increasing economic power, English bourgeoisie gained increasing political power. It indirectly shared political power with the aristocracy, through its influence on the Crown and its direct participation in the Parliament, but the capital importance of law and magistrates and the strength of parliamentary institutions helped control the army's political influence. Consequently, the rising bourgeoisie was not threatened with exclusion from power.

The army, the second chief stronghold of dueling, was never overinflated in England despite its great prestige after its victories over Napoleon. In fact, the army's impact on society was much weaker than in Germany, especially in Prussia (Frevert, 1993, p. 224). Moreover, in England, the second influential anti-dueling association was founded by the active participation of 35 generals and admirals in 1843 (Baldick, 1965, 113).

Embourgeoisement of dueling did not occur in England for two reasons: first, the semi-constitutional monarchy had strong parliamentary institutions and a relatively small and law-abiding army; and second, the early industrial bourgeoisie had a collective identity that was unthreatened by the working class and confident in its increasing economic and political power. Under such circumstances, dueling could only be tolerated insofar as blood feuds were still a menace; it remained an undesired form of anarchy with regard to order and law. The economic domination of the bourgeoisie under a state of law did not leave any room for this social institution, which was extinct by 1852. Abandonment of the duel was a clear sign of the approaching demise of the decadent aristocracy in England. Less than a generation later, the sharp decline of land rents from the 1870s onward completed its suppression by a very mixed plutocracy (Kiernan, 1988).

The emergence of dueling in England curbed blood feuds and contributed to a more regulated and restricted violence. Because the aristocracy and the army were bound to respect the state and laws, they could not prolong dueling beyond a certain level of maturity of the new order. Contradictory orders had a relatively short historical period that were dissolved and gave way to the rule of law.

French case: dueling as desired anarchy

As noted in the previous section, after the third quarter of the sixteenth century, only the French recklessly engaged in duels. The engagement was with such an ardor that no other country showed the French record of dead in dueling. In France, dueling was first practiced by poor, rootless, and aggressive gentry and petty nobility, many of whom served on both sides in the Thirty Years' War

(Billacois, 1990, 24). This schism of the French population between two faiths, Catholics and Protestants (which was aggravated by civil wars)[21], and the French path to absolute monarchy, were two reasons for dueling being embraced so vigorously in France.

As the Revolution approached, aristocracy and haute mercantile and financial bourgeoisie increasingly mingled. Their sense of fraternity and equality grew to the point that they could challenge each other freely; men without coats of arms could challenge or be challenged to a duel (Kiernan, 1988, 29). Dueling in France was a desired anarchy both for aristocrats and middle-classes; it represented a libertarian individualist anarchism as well as a leveler. Carlyle (1837) noted this leveling effect of dueling, "[A]ll Frenchmen have the 'right of duel'; the Hackney-coachman with the Peer, if insult be given! Such is the law of Public Opinion. Equality at least in death!" The duel was a *flexible* or *imitable* tradition in France and had a longer duration compared with England due to its embourgeoisement.

Contrarily to the English aristocracy, the French nobility adapted to the duel's embourgeoisement during the Restoration period. In contrast to the *British Code of Duel*, the publication of a new code of dueling in 1836 by the Comte de Chatauvillard and countersigned by men representing France's most illustrious families, including eleven peers of France and the cream of military elite (Jeanneney, 2004, p. 78) facilitated the duel's embourgeoisement. The widespread acceptance of this new code, the first of its kind since the seventeenth century, contributed largely to the predominance of a nonlethal type of dueling that is known as the "first blood duel" (*duel au premier sang*). As Chatauvillard put it in the *Essai sur le duel*, "in the present state of our manners, an ordinary duel (*au premier sang*) suffices the noble need to expunge an offense." (1836, p. 122). The author claimed that he was publishing this code because he regarded it as his "humanitarian duty to modernize and regularize a practice that was a necessary and inevitable feature of civilized life" (Nye, 1993, p. 137). It should be noted that first-blood duels were necessarily sword duels.

The predominance of first-blood duels is clearly reflected in the rise of épée dueling and that explains much of fencing's popularity: "Politicians, journalists, writers and businessmen -men in high risk categories- frequented the fencing halls to learn basic technique and stay fit" (Nye, 1990,

[21] Billacois (1990, 39) documents how in France, duels flourished when society was breaking into rival groups of Catholics and Protestants.

p. 371). Comte de Chatauvillard's code of dueling or the French aristocracy's adaptation to the idea of modernizing the duel was a major source of duel's embourgeoisement in France[22].

The French ministry of Justice, Tarde (1892), and Chesnais (1981) afford some statistics regarding the first half of the century, while Nye (1990, 1993) has compiled a master inventory of duels between 1860 and 1914 from a number of sources. The numerous shortcomings of these data notwithstanding[23], they provide a general scheme of what we name the duel's embourgeoisement. Borrowing upon the afore-mentioned sources, we have constructed a recapitulative table (Table 12) that documents the evolution of dueling from 1819 till 1900 with respect to the frequency of duels and their lethality rate. According to Chesnais (1981, p. 103), there were more than 832 deaths in the army for more than one hundred duels annually during the period 1819-1826. The number of total deaths decreased to 228 for the period of 1826-1834. It should be noted that Tarde's estimation is 189 deaths for the same period (1892, p. 51). The lethality rate was one third in this period. Since 1835 the average number of duels per year declines to one hundred (Nye, 1990, p. 371), and their lethality ratio also decreases from an initial rate of one third (33 percent) to almost 6 percent (three deaths over fifty three combats) in the 1870s (Chesnais, 1981, p. 109). Starting from 1880s until well into the 1900s, the dueling frequency began to increase rapidly, reaching a high of between 400 and 500 per year (Nye, 1990, p. 371). Tarde's estimate of 60 duels per year in the 1880s is far too low. According to Nye's conservative estimation, the average might be 200 duels per year between 1875 and 1900, and as late as 1911 one could still find as many as 5 duels taking place in Paris alone in a span of twenty days (Nye, 1993, p. 185).

Table 12: Evolution of dueling in France from the early nineteenth century till the First World War

Period	**1819-1826**	**1827-1834**	**1835-1880**	**1880-1914**
Frequency per year	>100	>100	100 on average	200 on average
Number and/or percentage of deaths	832	228 (33%)	$\geq$6% to $\leq$33%	< 2%

While the dueling frequency augmented rapidly after 1880s, its lethality rate drastically decreased to less than two percents for the period 1880-1914. This estimation is derived from Tarde's study (1892, p. 52) on the 1880s decade based on Ferréus's *Annuaire du duel* (see Table 13).

[22] It is noteworthy that when Chatauvillard's code was translated four years later (1840) into English, the Britannic press despised it as an evidence of the blossoming of a 'barbarous' practice (Kiernan, 1988, p. 262).

[23] Among these deficiencies, one can name the lack of the official *procès-verbaux* (report) provided by the seconds for the first part of the nineteenth century due to the lack of the mass press; the paucity of information regarding the duels in provinces throughout the nineteenth century, the private and unreported character of duels; the treatment of deaths caused by dueling as a homicide (*assassinat*), manslaughter (*meurtre*), or simple aggression; and finally the absence of any exhaustive research and documentation regarding dueling in general.

As this table indicates, only 431 duels over a total of 598 were fought, and the rest (almost a third) were 'arranged' and 'shunned' thanks to the active role of conscientious seconds in conformity with the rules of Chatauvillard's code of dueling. The total number of 16 deaths for 431 duels that were consummated in combats amounts to one death for 26 combats. The fact that dueling frequency doubled since 1880s, and nonlethal duels by épée became predominant indicate the prominence of civilian duels.

Table 13: Dueling frequency and its lethality in 1880s

Duels consummated in combats	Arranged duels	Total number of duels	Total number of deaths
431	167	598	16

To sum up, while the aristocratic duel was potlatch destruction (Vahabi, 2011), dueling in the Third Republic was a phenomenon of 'civilized' society of Parisian journalists, politicians and middle classes to build up a reputation capital.

German case: dueling as military order

The duel was imported to Germany as a French fashion, but it *never* represented *anarchy*; it always incarnated *order*, particularly military order. A double standard between 'military honor' and 'civilian honor' was instituted after the Prussian Law Code of 1794: a duel could only exist among officers and noblemen; armed clashes among other civilians, including the bourgeoisie, were handled by criminal law. Civilians were thus denied treatment under the dueling statutes. In the 1820s and 1830s, the German Bürger achieved the right to duel, and the switch from swords to pistols facilitated his participation. As in France, the duel became bourgeois in Germany, but the army, the one undeniably non liberal, non bourgeois institution in Germany, remained the duel's chief procurator[24]. The German army permeated civilian life in a multitude of ways and on a large scale; Frevet coined the term 'social militarization' to describe this process (1995, 36). Dueling blossomed in Germany especially from 1870–1914; *social militarization* thus led to the longest continuation of dueling in Germany, compared with England and France.

[24] As long as the officer corps had been recruited exclusively from the aristocracy, its honor had been aristocratic. But this altered with the growing recruitment of the officers from middle classes. "By 1861, nearly 20 percent of higher-ranking German army officers were bourgeois; although some regiments (notably the cavalry) had managed to maintain their exclusively aristocratic composition, others (such as the engineers, artillery, or supplies) had a higher than average number of middle-class officers. By the eve of the First World War, the proportions had shifted much further in favour of the bourgeoisie. By then, as many as 48 percent of Prussian generals and colonels were middle class, while three-quarters of the majors and first and second lieutenants were of bourgeois origin. Middle-class representation was particularly high in the naval officer corps, which had only been created under the Empire and had no aristocratic tradition to look back on." (Frevert, 1991, p. 275).

The double standard between civilian and military honor was maintained until the end of the nineteenth century. Max Weber alluded to this double standard when he wrote about contradictory orders. In 1848, Prince Wilhelm did not regard this coexistence of the military and civilian jurisdiction as 'anarchy;' for the King of Prussia and Emperor of Germany, the "apostles of anarchy" were those individuals whose primary concern was "undermining the honor of officers" (Frevert, 1995, 39). In contrast to France, in Germany the duel was neither a leveler nor a rebellion against order; it was a source of military order, hierarchy, and the caste system. Dueling for the honor of officers was a moral *duty* rather than an act of heroic voluntarism, which explains why the code of honor was not just a custom or a social value, but an obligation that was systematically enforced by the military jurisdiction.

Because dueling symbolized Prussian order, the opposition over civilian versus military honor became polarized. This opposition lasted until the end of fascism.[25] However, after the First World War, the nature of dueling radically changed. The first contributory factor in this process was the demilitarization of Weimar society, "a phenomenon which was reflected in the creation of a small professional army with a numerically insignificant officer corps" (Frevert, 1995, p.217). The second factor was the destabilization of the middle class during the crisis years of the Weimar Republic.

However, the situation changed with the rise of National Socialist. In 1933, the criminal law was rectified and student duels were expressly declared to be exempt from punishment, but this type of dueling was nonlethal and regarded as "student sabre duels" (Frevert, op.cit., p. 219). Although the nonlethal dueling was similar to the French fencing, there was a major difference: the German dueling could not be individualistic, "no German had the right to shed his blood for selfish reasons" (Frevert, op.cit., p. 225). In December 1938, Hitler announced that he was reserving for himself the right to sanction duels between officers. Henceforth, all duels in which party members proposed to engage required Hitler's sanction. Throughout the Weimar Republic and the Nazi era, the student dueling societies continued to exercise their influence. Despite their initial prohibition by the Allied Control Council in 1945, and the declaration issued at the conference of university vice-chancellors in October 1949, these societies succeeded in persuading the Federal Court of Justice to exempt the student dueling as a criminal offence (Frevert, op.cit. pp. 228-29). It was only after the reform of the German criminal law in 1969 that the dueling paragraphs from the criminal code were abrogated.

[25] Fascism resurrected dueling. Mussolini held dueling in reverence, and three years after Hitler seized power, dueling was legalized in Germany as 'the ultimate means for the defense of honor' under the supervision of special tribunals. At this point, the privilege was extended to all Germans, because as a member of *Herrenvolk*, every German was 'noble' (Kiernan, 1988, 53–54). According to Coombs (1997), Hitler was personally against the practice.

Table 15 summarizes the three cases of dueling in England, France, and Germany.

Table 14: A comparative representation of dueling in England, France, and Germany

Country	**Type of state**	**Place of army and parliament**	**Early or late industrialization**	**Duel of honor: anarchy or order**	**Duel's embourgeoisement**	**Historical duration of the duel of honor**
England	Semi-constitutional monarchy (state of law)	Balance of power between army and parliament	Early (industrial revolution)	Undesired anarchy	Absent (sudden end of dueling)	1590–1852
France	Bonapartism	Strong and active army versus weak and passive parliament	Intermediary	Desired anarchy	Present (gradual termination of dueling)	lethal dueling (from the second half of the 16th till 1880s), and non-lethal until 1918
Germany	Junker state	A state within the state (social militarization)	Late	Military order	Present (gradual termination of dueling)	Gradual termination: lethal dueling (from the second half of the 16th century till 1918), and non-lethal until 1950s

Experiments

Considering what was discussed over the three cases in England, France and Germany, in this section we test whether our model is able to replicate these cases and simulate the trajectory of dueling regarding its duration and intensity? More specifically, the model should show that

1- The duel takes longer in an environment which follows the situation in Germany, than an environment which simulates France, and then longer when the features of the case of France are considered compared to the case of England.
2- The duel should gradually shift from lethal to non-lethal and then disappear over time.

As it was mentioned, the available historical evidence cannot be quantified since no clear measure is available representing aristocracy unity, state and military power or the imitability of dueling across the time and location scopes of this paper. As a result, we define a set of random values to capture not the levels, but the differences between the countries in terms of identity, authority and embourgeoisement. To improve this value assignment, instead of using a single number to show, for example, the role of authority in England compared to France, we use two intervals each following a normal distribution, where if μ_1, μ_2, and μ_3 and σ_1, σ_2, and σ_3 represent the mean and standard deviation of the left, middle and right distributions, we then have: $\sigma_1 = \sigma_2 = \sigma_3$ and $\mu_i - \mu_{i-1} = \sigma_1$. We also run the models under $\mu_i - \mu_{i-1} = 2\sigma_1$ and $\mu_i - \mu_{i-1} = 3\sigma_1$ for verification purposes. Table 16 presents the selected initial conditions for each case.

Table 15: The applied values to simulate the differences between features of each country regarding the factor which are associated with duelling

	Case-specific Values				
	s.d. aristocracy	P_{state}	$P_{military}$	P_{imit}	*IS/IO*
England	N(0.25,0.05)	N(0.70, 0.1)	N(0.60, 0.1)	N(0.10,0.05)	N(0.70, 0.1)
France	N(0.15,0.05)	N(0.60, 0.1)	N(0.50, 0.1)	N(0.20,0.05)	N(0.55, 0.1)
Germany	N(0.15,0.05)	N(0.60, 0.1)	N(0.70, 0.1)	N(0.20,0.05)	N(0.55, 0.1)

Following the historical evidence, the model is set so that:

1. England has less aristocracy unity than France and Germany which have similar unity level. It should be noted that this distribution shows the standard deviation of aristocracy.
2. State Power is higher in England than both France and Germany which have similar values.

3. Military Power is higher in Germany than both France and England.
4. Imitation is lower in England than the other two cases.
5. Dueling is a more important component of aristocratic identity in England than France and Germany.

Figure 7 presents the dueling trends across three countries during the simulation. As can be seen, while the model is successful in providing a correct order on disappearance of dueling across the countries, the time scales do not follow what has been observed in the real world. This can be mainly due to the fact that we have not included many other country-specific variables, such as interstate conflicts or intrastate wars, or other social, economic or even cultural factors which may have contributed to the dynamics of dueling in these countries. The model also shows further variations in the case of Germany over the trend while the other two countries, England and France experienced similar levels of volatility.

Finally, Figure 8 decomposes the dueling trend to lethal and non-lethal. As it was reviewed before, in our simulated environment, lethal dueling is first substituted with non-lethal dueling and then both patterns disappear.

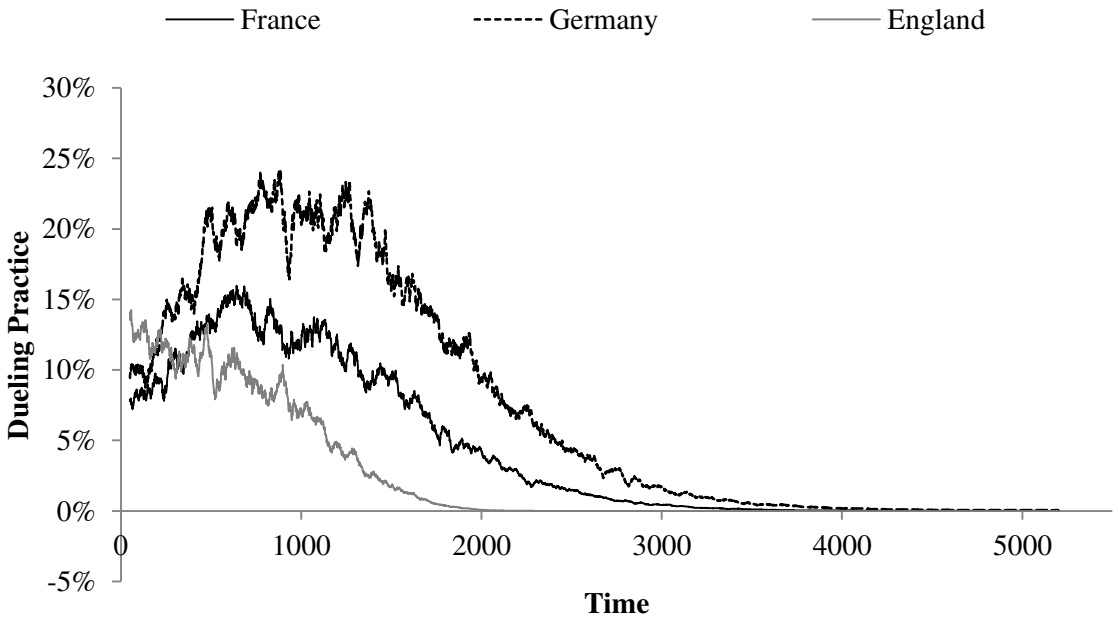

Figure 7: Duration of dueling in the three simulated cases.

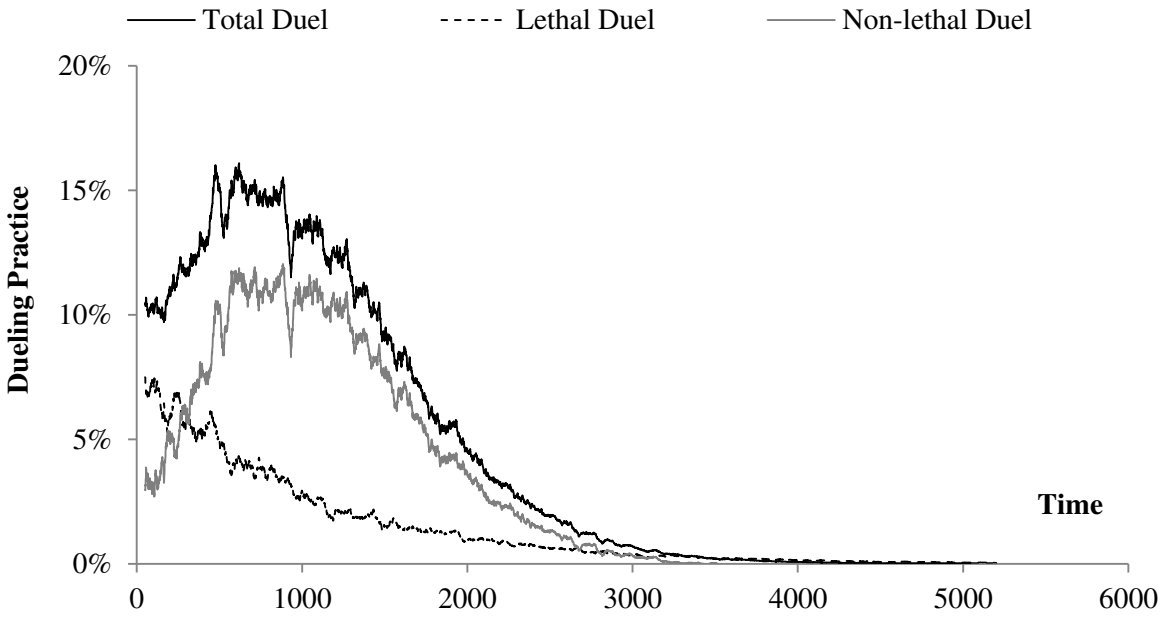

Figure 8: Decomposing dueling trend to lethal and non-lethal patterns.

IV. Conclusions

In their highly-cited paper, Einstein *et al.* (1935) present two questions which they believe can be used to judge the "success of a physical theory". The questions are, namely: 1) "Is the theory correct?", and 2) "Is the description given by the theory complete?" Einstein and his colleagues argue that the correctness of a theory in physics can be assessed by comparing what the theory concludes and what humans experience through experiment and measurement, while the condition of completeness is satisfied if "every element of physical reality has a counterpart in the physical theory."

In social sciences taking into account all the potential "elements" of a system may look impossible. In this paper, we attempted to show how, following what have been suggested by Tullock and other scholars, moving toward a more complete model of a public choice system, can provide us with more accurate results and a better understanding of how the system works and evolves when we explore the potential links between economics and politics.

To our knowledge, this paper provided, for the first time, a comprehensive theory on the main factors which have encouraged or dampened interest in dueling including the individual preference, network effects, role of identity, responses from authority and finally imitation probability.

Secondly, to examine the validity of our design, we presented an agent-based model capable of taking into account different factors and their possible complex interactions in order to explore the dynamics of duel of honor in Europe. Our results over the simulation steps and also the model validation outcomes showed that the introduced components are, to some extent, successful in explaining intensity (lethal and non-lethal) and duration of dueling across the case studies.

Thirdly, the replication of the historical emergence and evolution of dueling as an institution in England, France, and Germany by an agent-based model has a strong implication. It shows that a complex, aggregative historical process may be consistently explained on the basis of rational choice of *heterogeneous* individual agents conditioned by their group identity and authority (organizational) influence.

Our analysis of the evolution of order and the roles of identity and authority in shaping economic as well as political phenomena can be applied to understand the dynamics of developing and emerging countries with failed states where the state has not the monopoly of violence and different elite groups manage the conflict resolution in a self-regulatory way. The theory and model can be later improved by taking into account more case studies and also adding some country-specific issues in order to explain other aspects of duel of honor and hopefully will encourage more public choice scholars to use computational method to analyze real world systems.

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