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WHY DO ORGANIZATIONAL POPULATIONS DIE? EVIDENCE FROM THE BELGIAN MOTORCYCLE INDUSTRY, 1900-1993

Filippo Carlo Wezel[1]

SOM theme G Cross-contextual comparison of institutions and organisations

Abstract
Extinctions represent a potential outcome of the evolutionary processes of organizational populations. Nevertheless, scant effort, if none, has been dedicated to investigate this issue. This paper proposes three alternative hypotheses that may account for extinction events. They are drawn from very different literatures: economic geography, economic sociology, and evolutionary biology/paleontology. In particular, two of them rely on exogenous determinants, while one is focused on an endogenous reasoning. The theory presented is tested analyzing the entries of motorcycle producers in Belgium, a population that ceased to exist in 1981. The findings of this research provide evidence to support the internal causation of the event. The implications stemming from the present work are related to the literatures of population ecology and industrial economics.

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INTRODUCTION

Ecological theories are focused on the evolution of organizational populations/communities. As Lomi (1996, 28) suggested, the study of their evolution concerns six main sub-processes, each characterized by its own vital rate: (i) creation of new organizational forms (speciation rates), (ii) founding of new organizations (founding rates), iii) growth and contraction of organizations (growth rates), (iv) change in the existing organizations (rates of change), (v) disbanding of organizations (failure rates), and (vi) populations' extinction (rates of extinction). Organizational ecologists have widely studied foundings and failures, producing an impressive array of evidence in support of the density-dependence theory (see Carroll and Hannan, 2000, 218-219). By the same token, ecologists have extensively investigated the organizational processes related to change and growth. Amburgey, Kelly and Barnett (1993) and Barron, West and Hannan (1994) represent the 'state of the art' of the ecological research on these topics. Nevertheless, scant effort has been devoted to understanding speciation events (for a notable exception see Rao and Singh, 1999) and, particularly, extinctions.

Early studies on community development (Aldrich, 1979; Brittain and Freeman, 1980) clearly remark that organizational environments undergo fundamental transformations. On an empirical standpoint, political and economic forces are increasingly eroding the geographical barriers between nations, and industries tend to be more and more concentrated in space. Nonetheless, ecologists seem to forget that organizational populations may cease to exist (Aldrich and Wiedenmayer, 1993, 175-176). Why do organizational populations die? As Lomi, Larsen and Freeman note "this question is important because to the best of our knowledge no study is available to establish systematic links between demographic models currently used in empirical research and […] the extinction organizational populations" (2001, 36). This work deals exactly with this issue.

Given the lack of studies exploring this research question, the present work relies on an eclectic approach, drawing its theoretical framework from the literatures of economic geography, economic sociology, and evolutionary biology/paleontology. The theoretical reasoning will lead to the definition of three tentative hypotheses, two related to community-level causations, and one to internal competitive dynamics. These hypotheses will be tested with data on entries of motorcycle producers in the Belgian industry, during the period included between 1900 and 1993. The evolution of this population, extinct in 1981, represents an ideal setting to explore the research question presented. To reach these goals, the paper will proceed as follows. In the next section, theory will be introduced. Later, the data and the evolution of the motorcycle industry will be presented. Then model, and method used for the analysis will be illustrated. In the last two sections, results and their implications will be discussed.

ECONOMIC AND SOCIOLOGICAL ARGUMENTS FOR EXTINCTION EVENTS

Processes of extinction of organizational populations are poorly documented, and the theoretical development of this topic clearly insufficient (Aldrich and Wiedenmayer, 1993, 175-176; Lomi et al., 2001). Yet, paleontologists and biologists have extensively enquired this problem and already provided very different explanations - for an interesting review see McKinney (1997). In evolutionary biology in particular, one of the most widely used frameworks in textbooks (e.g. Sanderson and Moulton, 1998) is represented by the ‘evil quartet’ of Jared Diamond (1984). The latter includes the four most diffuse causes of populations’ extinctions, namely (i) habitat loss, (ii) species introduction, (iii) extinction cascades, and (iv) resource overexploitation. The following theoretical section builds on this categorization to provide three economic/sociological hypotheses mirroring the four aforementioned causes of extinction.

An ‘economic geography’ perspective on organizational population’s extinction

While ecologists have been mainly interested in studying individual populations, Astley (1985) and Zucker (1989) were among the firsts to challenge this idea. Zucker, for instance, noted that measuring the density of a single population does not control for those environmental changes involving entire communities. Therefore, accounting for sovra-national evolutionary dynamics is relevant because individual populations are linked to broader communities by "ties of commensalism and symbiosis through their orientation to a common technology, normative order or legal regulatory regime" (Aldrich, 1999, 301). A similar perspective to communities sheds light on their two main characteristics: the relations between its members (i.e. populations), and the boundaries existing among them. The definition of boundaries assumes particular relevance since community-level evolution mostly occurs through the effacement of borders between populations (DiMaggio, 1994, 445). The latter may take place either because of (i) cognitive, or (ii) geographical determinants. On the one hand, cognitive boundaries are nowadays falling between communication companies and computer firms. On the other, several ongoing processes – i.e. political and economic - are at work to erode the geographical boundaries between national entities. The geographical component of evolution is worth noting, since ecologists often define populations in terms of political entities, namely as nations (Hannan et al, 1995). Therefore, one potential reason to investigate the extinction of an organizational population can be related to the evolution of communities as geographical entities.

Economic activities tend to be concentrated in location for different reasons. Marshall (1922) underlined three main benefits deriving from co-locating economic activities. *First*, an extended division of labor generates economies of specialization. Outsourcing is in fact a typical feature of industrial district (e.g. Piore and Sabel, 1984). Clustering helps also firms to share the benefits of economies of scale, and it promotes technological innovation (Chinitz, 1961). *Second*, proximity generates economies of information (Scherer, 1984). Since the transfer of tacit knowledge requires interpersonal contacts, firms' proximity assumes relevance in facilitating knowledge sharing. *Third*, clustering promotes economies of labor supply. Workers can more flexibly adapt to the demand of geographically concentrated organizations. Nonetheless, clustering significantly influences the spatial structure of economic systems. Simulation studies for instance have showed that transportation costs are responsible to produce a geographical bifurcation of a system in two regions (Krugman, 1991). Krugman and Venables (1995) developed a model of international trade in which falling transportation costs may lead to a division of the world into core and peripheral economic systems. Similarly, Krugman (1993), using racetrack models,[i] regularly illustrated the emergence of a spatial structure – most of the time with two agglomerations - in a simulated economy. Overall, the evidence provided by this literature suggests that, in order to preserve the existence separate economic systems, a minimum geographical distance between them should exist.

In a similar vein, human ecologists – e.g. Park (1925) – have widely studied the emergence of social (and spatial) order. According to these authors human activities tend to assume an orderly arrangement in space, which ultimately leads to the formation of 'human ecologies' whose boundaries are spatially or geographically delimited. The geography of localized populations generally comprises "a patchwork of local areas differentiated from one another by cultural, racial, or linguistic peculiarities" (McKenzie, 1968, 73). Yet, these authors recognized that boundaries evolve – and even disappear – over time, and division of labor may be seen as one of the variables responsible for the evolution of the spatial-temporal structure of ecosystems. As Hawley (1986, 106) suggested, the regional and interregional division of labor induces three main consequences. "First, the biophysical environments of each formerly semi-independent system are merged in a single biophysical environment from which all draw sustenance. Second, whereas the once semi-independent systems were…the expansion process converts them to a status of subsystems in a more inclusive system. Third, system growth absorbs an increasing proportion of the ecumenic environment into the system." By the same token, Lomi and Larsen (1996) more recently have remarked the sociological implications stemming from organizational proximity. Using a minimal set of assumptions on interactions among firms, they simulated the evolution of an organizational population finding that in presence of particular circumstances of their experiment – i.e. minimum number of actors -, organizations were not able to survive outside localized clusters.

The arguments proposed so far seem to suggest that processes of co-location may erode the boundaries between separate entities, and potentially dry up the resources available in neighboring areas. A similar hypothesis finds also support in a paleo-biological view of extinction vulnerability: isolated species are more prone to extinction (McKinney, 1997). In light of this discussion, I hypothesize:

Economic geography hypothesis (H1a): Neighboring populations erode spatial boundaries,
promoting the dissolution of those more narrowly defined.

A 'historical efficiency' perspective on organizational population's extinction

One of the most important contributions of the Malthusian research has been to acknowledge the resource scarcity of the environment. This condition limits the growth of species, boosting the competition among them. Building on this intuition, most of the evolutionary research (on organizations) assumes that competitive processes promote historically efficient outcomes (Carroll and Harrison, 1994). As March and Olsen (1989, 5) explained, "[I]nstitutions and behaviors evolve through some form of efficient historical process. An efficient historical process, in these terms, is one that moves rapidly to a unique solution, conditional on current environmental conditions, and is independent of the historical path. This equilibrium may involve a stochastically subtle distribution or a fixed point, but we require a solution that is achieved relatively rapidly and is independent of the details of historical events leading to it." This reasoning implies that the structure of modern organizations represents the outcome of an efficient process of competition: evolution maximizes the fit of the organizations with the environment, and with the limited amount of resources of the latter.

Mirroring the Darwinian reasoning, ecologists, maintain environmental discontinuities to favor organizations better fitting the environment, implicitly recognizing historically efficient processes. Environmental shifts promote selection because organizations are inert in reacting to environmental changes (Hannan and Freeman, 1984). Organizational environments consist of different dimensions. Capital, knowledge, personnel, equipment and customers represent some of these dimensions; others can be identified into all the social, political, economic and historical conditions that sustain the functioning of an organizational form. Following

Hannan and Freeman’s rationale, changes in each of these dimensions may be responsible for environmental selection. Political instability, for instance, may disrupt the established ties between organizations and resources, boosting new entries into the industry (Stinchcombe, 1965). In a similar vein, changes in technology may destroy the existing knowledge (Tushman and Anderson, 1986) promoting organizational turnover.

Yet, inertia is not merely an organizational feature. In a recent paper, Hannan (1997) has introduced a similar concept at population-level. Populations react with delay to environmental changes, and this is one of the reasons why they often are at different sizes from their carrying capacity (Carroll and Hannan, 1995). The New England’s ice economy (Botkin, 1988; Lomi, 1996), the Swiss watch industry (Carroll and Hannan, 1995) and the television industry (Dimmick and Rothenbuhler, 1994) represent three excellent examples to provide evidence of community succession/predatory competition among populations. The ice economy – i.e. extraction of natural ice and in its conservation - between 1620 and 1870 represented the main economic activity of the area surrounding Route 128 in Massachusetts. Due to the introduction of mechanical production of ice, all the organizations of the area failed and that economy went extinct. A similar change marked the evolution of the Swiss watch population. In 1945, nine of ten watches throughout the world were produced by Swiss firms. After ten years, the success of this industry was suchlike that 2.300 firms existed in Switzerland. In the 1980s Japanese producers introduced the quartz watch technology, and few Swiss firms, at that time mostly producing mechanical watches, adapted to the new environment. In few years over 1.600 Swiss firms failed. Last, not differently from the previous two examples, a similar predatory competition is currently taking place in the United States, where the increasing diffusion of cable channels represents a serious threat for the existence of broadcasting televisions.

Thus, historical efficient evolutionary processes not only relate to intra-population dynamics, but also to interactions among several organizational populations (Carroll and Harrison, 1994). Populations better fitting transformed environments may be responsible for the extinction of those less adapted to it. A similar process is in the field of bioecology known as ‘competitive exclusion’. Gause (1934) coined this term to indicate that the mix of two populations, depending on the same fundamental niche, leads to the disappearance of one of them. In light of this discussion, I an alternative hypothesis to the H1a is:

Historical efficiency hypothesis (H1b): Populations better fitting the (new) environment promote the selection of those poorly adapted.

An endogenous perspective on organizational population’s extinction

The hypotheses proposed so far maintain that populations can disappear either because they are unable to adapt to changing circumstances (H1b), or because other populations invade their niches (H1a). Thus, these two explanations rely on exogenous circumstances and do not account for internal determinants of extinctions. Yet, the competitive interactions among organizations represent a key element of the evolution of a population. Two processes are potentially prone, more than others, to support a theory of population’s extinction as an internally dependent phenomenon, namely (i) vacancy-chains, and (ii) co-evolutionary processes.

Organizations do not exist as isolated entities. They operate in a system of concatenated roles (White, 1988), which represent a source of opportunity and constraints for them (Podolny et al., 1996). Drawing from this intuition, Lomi and Larsen (2001) have recently simulated vacancy-chain models of failure. Assuming that organizations are simultaneously network and occupants of specific position, they challenge the idea of failures as independent organizational events. On the contrary, they investigated firms’ mortality in terms of an exit from a social structure of interconnected roles. They argue that the disappearance of an organizational unit vacates positions in a resource space. Therefore, “the effects of individual mortality events may propagate within an organizational population and affect the life chance of other organizations by triggering “vacancy chains-like” processes throughout a system of concatenated roles and positions” (Lomi and Larsen, 2001). Their findings demonstrate that the effects of individual failure events may propagate through the entire organizational population. In particular, single failure events can lead either to local, or global consequences, depending on the underlying structure the network of relationships. A similar idea found also support in the evolutionary biology literature. Cascade effects can be triggered by the removal of keystone species (e.g. Owen-Smith, 1987). Keystone species, like keystone organizations, are probably the inevitable result of the evolution and are especially important because of their large impact on populations' stability. For this reason, their removal from a population can generate nonlinear effects, causing extinctions to cascade throughout systems (Solé and Montoya, 2000). These theoretical arguments suggest that organizational mortality has potential micro-macro consequences: individual organizational failures may be devastating for the population as a whole.

A second theoretical motivation that might justify internal determinants of extinction is represented by mechanisms of system-dependent selection. In theoretical biology, these evolutionary regimes are used to analyze the dependency of vital rates from the feedback existing between populations and their environments (Wilson and Agnew, 1992). Lomi, Larsen and Freeman (2001) have modeled the co-evolution of organizations and their resources through a simulation of a system-dependent selection process. In their formulation, they define the carrying capacity of the population as the byproduct of resources' consumption and regeneration. Their findings provide evidence that, in dynamic environments with endogenous carrying capacity, specific levels of population inertia are systematically associated with extinction. This outcome is possible "because the effects of density on organizational vital rates (mortality and founding) do not change sufficiently fast to compensate for the over-consumption of resources" (Lomi, Larsen and Freeman, 2001, 28). Over-consumption takes place because firms may abuse of the immaterial resource they jointly own, namely the legitimation of their organizational form. A similar behavior is responsible of what the authors have labeled - drawing from Hardin (1968) – as the "tragedy of commons", promoting the extinction of the organizational population.

The description of these last findings allows me to complete the 'evil quartet' proposed by Diamond (1984). While hypotheses 1a and 1b were focused on habitat loss (i) and species introduction (ii), this last section relates to (iii) extinction cascades, and (iv) resource overexploitation. Therefore, to be consistent with the evil quartet-model I introduce an alternative hypothesis to extinction, focused on the internal dynamics of competition:

Self-destruction hypothesis (H1c): Internal competitive dynamics are responsible for the extinction of organizational populations.

To summarize this theory section, I proposed three alternative hypotheses that may account for the extinction of organizational populations. Assuming that, to the best of my knowledge, no study exists that produced falsifiable hypotheses on this topic, I developed my theoretical reasoning combining the literatures of economic geography, economic sociology, evolutionary biology and paleontology. Two of the hypotheses presented rely on external determinants of extinction - H1a and H1b -, while one - H1c – is focused on an endogenous rationale. The arguments illustrated will be tested with data on entries of producers in the Belgian motorcycle industry, extinct in 1981.

METHODS

Data

In choosing the populations for this research, I opted for the Belgian motorcycle industry for four main reasons. First, the evolution of this population, extinct in 1981, represents an ideal setting to explore the aforementioned research question. Second, the nature of this industry, global but at the same time nationally heterogeneous represents an ideal field to test hypotheses on multi-level processes. Third, data availability allowed me (i) to collect observations at multiple levels of analysis, and (ii) to avoid problems related to left truncation. The advantage obtained is to study entries over the complete history of the population. Last, the significant body of research on the ecological dynamics of automobile organizations includes the analyses of the Belgian industry (e.g. Hannan et al., 1995) and, thus, greatly facilitates comparison and accumulation of empirical results.

The main source of information comes from the book “The Complete Illustrate Encyclopedia of the World’s Motorcycles” (Tragatsch, 1977; 2000) considered the most reliable text for this industry, and from the “Enciclopedia della Motocicletta” (Wilson, 1996) that includes the date of birth and disbanding of each firm in these countries. The year in which the first model appears in the books was considered as the year of birth of a firm and the year in which the last model disappears from the register was coded as death. In order to test the accuracy of the data, we checked the magazines of the period: *Motor Age* (from 1899), *Cycle Trade Journal* (from 1897), and *Motor* (from 1903) were consulted for this reason. Finally, we crosschecked all the information with other references: “A-Z of Motorcycle” (Brown, 1997), “Historic Motorcycles” (Burgess Wise, 1973), “The Ultimate Motorcycle Book” (Wilson, 1993), and “Encyclopedia of Motorcycling” (Bishop and Barrington, 1995) confirmed the reliability of the data presented.

The evolution of the worldwide motorcycle industry: an overview

Since I am using a new data set, it may be useful to present a brief description of the industry. The origins of the motorcycle industry can be traced back to the 1885. In that year, Gottlieb Daimler created the very first motorcycle in the world (Bishop and Barrington, 1995). To be right, it was just a prototype and he soon abandoned it. Thus, Hildebrand and Wolfmuller of Munich can be considered the first real manufacturer. However, their experiment was not that much successful. Better success had the Colonel Holden in England, and Count De Dion in France in partnership with Bouton, who, at the end of the ninetieth century, opened the door to the new industry. In 1897, De Dion offered his engine for general sale, enabling scores of experimenters to copy and to improve upon. He obtained an outstanding penetration of the market and became one of the most important engine manufacturers. Needless to say, he soon had many rivals, of which the Belgian Minerva and the French Clement were the most popular (Tragatsch, 1977). In particular, during the early years of 1900s, the Belgian Minerva and the FN were among the most diffused engines on many motorcycles sold in the United Kingdom and Germany.

The definition of a standard position for the engine, in the early 1900s', facilitated the spread of production of motorcycles in many European countries. In the meantime, social events, like exhibitions and competitions, helped manufacturers to build their reputation and to convince people about the reliability of the new products. In 1903, in London, took place the first important exhibition, "The Stanley National Show", and in the same year, the Autocycle Club, opened to all motorized vehicle, was born in England. In 1904 the Motorcycle Club de France and the Fédération Internationale des Clubs Motocyclistes were founded. The first recorded national race was held in 1897 at Richmond (Great Britain), whilst the first international competition took place in 1904 in France, namely the International Coupé Race (Bishop and Barrington, 1995). The world famous race, the Tourist Trophy, was held for the first time in 1907 in the Isle of Man, off the West Coast of England.

The positive economic climate of these years promoted the growth of national industries throughout Europe. In 1904, new registrations reached 21,974 motorcycles in the UK and 19,886 in France, the same number than that of cars (Tragatsch, 1977). Italy, while slowly growing, was steps behind these two leading countries. As an indication of it, the first motorcycle club in Italy was founded only in 1911. At that time, the Japanese industry was just born and its national production was almost negligible. The arrival of the Great War consolidated the emerging landscape and the European supremacy in the worldwide motorcycle production. In fact, seeing the possibility of extra-sales, Scott and Triumph in United Kingdom, NSU in Germany, FN in Belgium vied each other for the lucrative Government orders (Collins, 1998).

The years following the WWI were marked by an increasing mercantilism: exchange restrictions and severe controls on both capital and labor limited the growth of international trade (Maddison, 1991). Motorcycle factories that had produced arms throughout the war had to redesign their models and to re-train their staff in new manufacturing techniques. A market for secondhand bikes emerged for a while. Nevertheless, the demand for these used products declined as soon as the factories were ready to offer new motorbikes. During these years, Germany and France saw an upsurge of interest in motorcycling and a number of imaginative and advanced designs were produced (Wilson, 1996). The Golden age of motorcycle saw the light and after 1919 the demand growth was high, in all the European countries.

Yet, between 1929 and 1934 things changed, and the home and export market in the Great Britain suffered a massive flop: the overall production dropped from 147,000 to 58,500 units, and the exports collapsed to 16,807 (Koerner, 1995: 57). Two main reasons favored the explosion of other European countries. Firstly, motorcycles remained technologically stagnant, in comparison with the progress of the motor-car industry: electric-starters, all metal bodies for better weather protection, as well as significant safety improvements. The lack of technical progress of the United Kingdom industry was indeed compared with products more advanced coming, for instance, from Germany and Italy. Secondly, in France and Germany, the Government reduced or simply removed the tax and regulations for motorcycles under 200cc. engine capacity. On the contrary, the SMMT – the Society of Motor Manufacturers and Traders – was unable to persuade its members to reach a unified position on taxation, despite the repeated invitations from the government to do so (Koerner, 1995). The net result was that during the late 1930s the German industry became the first European producer and the biggest exporter – 1937: 31,307 exports for Germany and 25,350 for the UK.

In the meantime, the Spanish Civil War gave the chance to FN to sample first hand the excellence of Belgian military motorcycles (Tragastch, 2000: 36). The Second World War and the shortage of fuel in supply after the end of the war generated a big demand of economical transport. The Japanese motorcycle industry, in decline during the early Thirties, was saved by the military build-up. Yet, at that time, most Japanese bikes were copies of either European or American designs and some were very crudely built.

Eventually, a new economic cycle began and the gradual and substantial freeing of capitals of the Fifties helped the international trade grow. The demand of motorbikes increased rapidly throughout the world. Smith (1981: 13) calculated that in the period included between 1953 and 1975, the world production of motorcycles increased of five times. One of the reasons of this growth is related to the development of the Japanese industry. In 1948 in fact Soichiro Honda established the

Honda Motor Company Ltd. While until the early Fifties the Japanese production was very small – 1951: production 24,153 and export just 491 motorcycles (Smith, 1981) - , since the Sixties Japan emerged as the world's leading producer – 1965: 1,875,614 motorcycles. In a few years the market became progressively polarized "into stylishly dressed scooter and leather-clad racers who rode and lived for their bikes" (Tragatsch, 2000: 48). The change in the environment favored those countries more experienced in producing small capacity motorcycles. Japanese manufacturers gained momentum, and their exports became soon very high in Great Britain. In France and Italy, on the contrary, governmental restrictions protected the national markets. During the same period, United Kingdom and Germany, uncomfortable with the way motorcycling appeared to be going, fell behind Italy that gained the best position in the market. Production in Great Britain fell from 154,000 in 1953, to 70,000 in 1970. Similarly, the production in Germany declined from 576,000 motorcycles in 1953, to 285,000 in 1975. On the contrary, during the same years Italy emerged as the first European producer – 1974: 1,040,250 motorcycles -, and exporter.

Today, Japan is clearly the leader in the United States (78% of market share) and in its national market (98%), whereas Italy leads the European production, accounting for 50% of the mopeds production and 70% of all the motorcycles produced in the European Union (ACEM, 2000). Clearly these two countries represent two competitive advantaged countries in the motorcycle production – 1998: Japan produced 1,062,980 and exported 1,413,133; during the same year Italy produced 1,027,125 and exported 524,960 motorcycles (mopeds included). While the most important European nations experienced great increment of the demand for motorcycles, the Belgium market stalled. The total number of bikes registered rose from 94,000 to 175,000 between 1970 and 1993, but the demand for new motorcycles then fell to about 42,000 units in 1995 (ECMT, 1998).

Figure 1 and 2 present the level density and the births of all the 97 firms that operated in the Belgian motorcycle industry during the period 1900-1993. The increase in producers displayed by Figure 1 was steep during the first decade of the history of this population. Then, after two distinct boom and bust cycles, the population reached its historical peak of 24 manufacturers in 1951. The progressive decline drove this industry to its extinction in 1981. As Figure 2 shows, no new producer entered the industry since that year.

Insert Figure 1 and 2 about here

Variables

The models presented in the empirical part include as independent variables, i) organizational densities measured at different level of analysis and industry age, ii) a number of controls factors measured at national level, and iii) a set of periods effects to account for institutional and significant changes in the history of the motorcycle production. The dependent variable is the yearly organizational founding rates.

Densities are defined as the total number of motorcycle producers active in each year of observation – *National Density*. As commonly used in the ecological literature, the first order effect of this variable estimates the level of legitimation of the organizational form, whereas, the second order effect measures the degree of competition (Hannan, 1986). In order to test hypothesis 1a, I measure the competition received by Belgian producers from neighboring states creating a variable summing the squared values of density in France and Germany – *Neighbors Density*^{2}. Similarly, to test hypothesis 1b, I account for the competitive strength of Japanese and Italian producers through two variables, *Japan Density*^{2} and *Italy Density*^{2}. Last, hypothesis 1c will be tested estimating the effect of the squared value of the number of national producers - *National Density*^{2} - on the founding rate.

The models presented contain a clock labeled as *National Industry Age* to control for calendar time. This was calculated as the difference between 1900, year of beginning of the industry, and the observed year. Three variables are included in all the analyses as covariates to account for changes in the level of resources available. To control for the general economic climate and for the degree of development of Belgium, gross domestic product - *GDP* - and the length of railways - *Rail* - were inserted, using data from Maddison (1991) and Mitchell (1998), respectively. Last, in order to control for cycles of entry, the number of firms founded at time t-1 - $Entries_{t-1}$ – is inserted in the model (Delacroix and Carroll, 1983).

Period effects

In order to avoid misspecifications,[ii] I left the entry rates freely change over historical periods in response to unmeasured environmental conditions. To account for the different histories of the national industries, I defined nine dummy variables to trace the main evolutionary periods of the Belgian motorcycle industry. The dummies were set equal to one within the segment of observation and put equal to zero outside. Each effect measures the change in the rate in comparison to the omitted category. The first periods were defined starting from the years of publication of the "Manuale Hoepli del Motociclista", released in 1903, 1909 and 1915. The objectivity of this choice is guaranteed by the fact that this publication had to be updated in the year in which the old edition was considered obsolete for the technology of the period. These periods mark the years of increasing international trade and economic growth allover Europe (Maddison, 1991). The years included between 1915 and 1918 are those of the First World War. After the WWI the economic climate changed and protectionism became a common trade policy. Exports declined dramatically. Yet, the enthusiasm around motorcycle production reached its apotheosis. The turn of 1926 - peak of density in many European countries - signed the beginning of a new era defined as "new look", during which the aesthetic design went side by side with the functionality of the products: motorcycles were designed using less angular shape, the rounded tanks begin to be diffused and the saddles become anatomical (Tragatsch, 2000). Indeed, in the same years, Europe becomes the core of the world automobile production (Hannan et al., 1995). 1939, marks the beginning of the Second World War. Last, 1958 indicates the symbolic year of start of the Japanese era, as well as the beginning of international free trade.

Model and method of analysis

To study the founding rates of motorcycle organizations I employed event history analysis techniques (Tuma and Hannan, 1984). The founding of each new motorcycle producer is assumed to be a realization of an arrival process. I model the rate at which these founding events occur at a particular time, *t*, conditional on the values of observed covariates and on the event not having occurred prior to time *t*. This rate, *r*[t|X(t)], is generally known as the hazard rate. It is formally defined as follows:

[1]

$$\lambda(t \mid X[t]) = \lim_{\Delta t \to 0} \frac{\Pr(t+\Delta t > T \geq t \mid T \geq t)}{\Delta t}.$$

A log linear function is used throughout to relate observed covariates, X(t), to the rate. This is standard practice to ensure that the estimated rate must be positive. The simplest possible hazard rate model assumes that λ(t) is constant over time. That is,

[2]

$$\lambda(t) = \exp[\beta' X(t)],$$

where ß is a (*k* x 1) vector of parameters to be estimated and ***X(t)*** is a (1 x *k*) vector of exogenous variables.

For the data collected for this research, the year represents the unit of interval and, therefore, this expression can be considered to refer to the yearly flux of entries in the Belgian motorcycle population. The Poisson regression represents the most appropriate solution for studying dependent variables that take only integer values. Nevertheless, under the assumption that the process of founding follows a Poisson distribution, one potential problem is represented by overdispersion, namely the tendency of the variance of the founding rate to increase faster than its mean. Although this problem does not affect the coefficient estimates, however, standard errors might be underestimated and therefore chi-square values overestimated (Allison, 1999). In the case of the Belgian data, the overdispersion arises from the years with zero foundings, namely from the extinction of the population. Therefore, I used an econometric model designed for this problem, namely the zero-inflated Poisson (Greene, 1999; Carroll and Swaminathan, 2000). The model for Y_t the number of foundings in each year is given by two equations: 1) $Y_t = 0$, with probability q_t, and 2) $Y_t \sim \text{Poisson}(\lambda_t)$, with probability $1-q_t$. This model implies that the $\text{prob}(Y_t = 0) = q_t + [(1-q_t)R_t(0)]$, and $\text{prob}(Y_t = j) = [(1-q_t)R_t(j)]$, where $R_t(y) \sim \text{Poisson}(\lambda_t)$ and the rate of the event $\lambda_t = \exp(\beta' X_t)$. The probability of $q_t \sim \text{logistic}(\nu_t)$, where $\nu_t = \gamma' Z_t$. In the zero-inflated model, X_t is a vector of variables influencing the non-zero counts, and Z_t represents a vector of measures that influence the zero counts. I expect the years after WWII and the Japanese era to be marked by higher international competition and thus, I supposed these years to depress the entries, and to increase the likelihood of zero founding events. Therefore, I included a dummy variable – *Post Second World War* - in the part of the model that predicts the zero counts.[iii]

Finally, as the models presented are not nested, following Lomi (1995), the $\overline{\rho}^2$ statistics will be used to compare them (Horowitz, 1983). The $\overline{\rho}^2$ test for model specification is a likelihood ratio test adjusted to account for differences in degrees of freedom across non-nested model and is defined as follows:

$$\overline{\rho}^2 = 1 - \frac{L_f - \eta_f}{L(0)} \qquad [4]$$

where $\mathbf{L_f}$ is the log-likelihood of the full model, η_f is the number of parameters, and $\mathbf{L}(0)$ is the log-likelihood of the restricted model containing a constant term only. The model with the highest $\overline{\rho}^2$ value is the one that best fits the data. All the covariates were lagged of one year to avoid problems of simultaneity. The estimates were obtained using STATA version 6.

RESULTS

Table 1 presents the estimates of the zero-inflated Poisson models of the founding rates for the entries of motorcycle manufacturers in the Belgian population during the period included between 1900 and 1993. The table contains the estimates for two different equations. The first part presents the values obtained from the Poisson regression to measures the probability of obtaining *non*-zero counts, whereas the second part illustrates the estimates deriving from the logistic regression that measure the probability of observing zero-counts. Model 1 is referred to hypothesis 1a relative to the 'economic geography' explanation, Model 2 and Model 3 measure the influx of the Italian and Japanese rivalry (H1b), whereas Model 4 tests the consequences of the internal competitive dynamics on the founding rates (H1c).

Insert Table 1 about here

An overview of the control variables suggests some consideration. The estimates obtained for the period effects show a general tendency of entries to decline with time. Periods 3 (1909-1914) and 5 (1919-1925) present rates of entries significantly higher than the omitted category (1958-1993), whereas the WWI clearly depressed the foundings. The estimate obtained for $Entries_{t-1}$ confirms the hypothesis advanced by Delacroix and Carroll (1983): entries follow cyclical patterns. Each firm founded at t-1 promotes an increase in the probability of other entries at time t of about 14% [exp(.135)]. It's interesting to note that the development of railways significantly depressed the entry of new firms in the industry. This result may suggest that in small countries like Belgium, motorcycles and rail represent two alternative means of transportation. Last, like in other studies, the growth of the GDP results negatively related to the entries of new organizations.

All the models presented in Table 1 assume the legitimation process to be fully national. The reasons to support this claim are at least two. First, as the section on the evolution of the worldwide motorcycle industry suggests, Belgium represented one of the most important European engine producers. During the early years of 1900s, the Minerva's and the FN's engines were components many famous motorcycles sold in the United Kingdom and Germany - i.e. Triumph (1902), James (1902) and Allright (1903). Second, exploratory analyses provided support to this theoretical intuition.[iv] The linear estimate of *National Density* is highly statistically significant in each of the models presented in table 1. On average, an increment of one unit in the number of manufacturers increased the probability of new entries by about 24% [exp(.216)].

Different combinations of the squared term of density – referred to competition – are used to test the hypotheses 1a to 1c. Model 1 suggests that the growth of neighbor populations – i.e. France and Germany – depressed the entries in Belgium. Nevertheless, the coefficient obtained is far from being statistically significant. In a similar vein, Models 2 and 3 test the competition that the Belgian producers received from Italy and Japan, respectively. I chose these countries as representative of the environment that follows the Second World War, because of their increasing importance during the last sixty years. After 1945 – the period in which the value of the density in Belgium was depressed (see Figure 1) - these two countries emerged as the world's best producers and exporters[v] (Smith, 1981, 16; Tragatsch, 2000). Moreover, the growth of Japanese industry has been claimed to be the cause of decline of the Great Britain motorcycle industry (Boston Consulting Group, 1975). Therefore, these nations can be imagined as historically efficient competitors for the period following WWII. Yet, none of their squared terms of density – *Italy Density*^{2} and *Japan Density*^{2} – seem to have a significant impact on the decline of the Belgian industry. On the contrary, the addition of the national squared term of density – *National Density*^{2} – greatly improves the fit of the model. A comparison of the values of the $\bar{\rho}^2$ statistics supports this claim. Internal competitive dynamics significantly depressed the entries.

Two other points merit attention. First, regarding the lower part of the table, the addition of the term controlling for the national level of competition influences the effect of the coefficient of *Post Second World War* that controls for the probability of obtaining a zero count in the dependent variable during the period 1946-1993. Inserting *National Density*^{2} renders statistically significance the probability of observing zero foundings in the Belgian population. On the contrary, Model 1, 2 and 3 do not explain why during the same years this industry does not experience new entries. Second, note that adding the variable of national competition increases of about a half the estimate obtained for the linear term of density (.312 versus .217). In general these findings strongly support the idea of evolution of this industry as a fully internal process (H1c). To measure the relative efficacy of this explanation, Figure 3 reports a comparison between the effective and the estimated values of entries based on the information obtained in Model 4. On a qualitative standpoint, it seems fair to conclude that the national model of evolution mirrors quite well the empirical process.

Insert Figure 3 about here

Nevertheless, the qualitative analyses presented in Table 2 shed light on a more fine-grained interpretation of the density-dependence findings. All values reported in that table were created using the estimates obtained in Model 4 of Table 1. Column two and column three (N_{min} and N_{max}) offer information about the historical evolution of the Belgian population. The following column, presents the value at which the multiplier of the founding rate reaches its maximum value (λ^*), while column 5 provides the estimates for this value (N^*). Column six contains the value of the multiplier rate at the maximum of the observed density of the population [$\lambda(N_{max})$], and the last value [$\lambda(N_{max})/\lambda^*$] presents indication of the drop of the founding rate from its peak as density goes from the expected value N^*, to the observed N_{max}. In particular, the estimates of λ^* and [$\lambda(N_{max})/\lambda^*$] can be used to interpret the direct effect of density-dependence legitimation and competition on the founding rate.

Insert Table 2 about here

Following these values obtained, the multiplier of the founding rate reaches its maximum when the population density was at 16. At that value, the founding rate increases by more than twelve times as the rate does when N=0. This result offers an idea of the importance of the legitimation process for this population. The value of the multiplier at the estimated maximum - $\lambda^*=12.48$ - is similar to that found by Hannan and Carroll (1992) for Manhattan Banks ($\lambda^*=10$). Interestingly, it is not far from the estimates obtained by Hannan et al. (1995) for the Belgian auto producers ($\lambda^*=8.8$), suggesting the existence of a potential relationship between these two productions. The values obtained for density-dependence competition deserve particular attention. The process started to depress the founding rate of this population at a value of density very close to the historical peak. Thus, increments of density beyond 16 to the maximum observed in this population (24), depressed the multiplier of the founding rate by 45% [$\lambda(N_{max})/\lambda^*=.55$]. This value is consistent with the estimates found by Hannan et al. (1995) for the France and British auto industry. Carroll and Hannan (1989) found a similar relationship between density and founding rates for the population of newspaper organizations Argentina. Last, comparing this value with those obtained experimentally by Lomi and Larsen (1996), we find that this outcome is typical of populations characterized by patterns of interaction localized. In general, these results show a significant effect of density-dependence competition within the Belgian motorcycle industry. Yet, the estimates obtained both for legitimation and competition appears not to significantly differ from other still living populations. Thus, these findings cast some doubts on the explicative power of the density-dependence mechanism in explaining the sudden decline of the Belgian motorcycle industry.

DISCUSSION AND CONCLUSIONS

Different authors have recently claimed that a complete analysis of the evolution of organizational populations should also account for extinction events. Aldrich and Wiedenmayer (1993, 176), for instance, stated “community studies often focus on areal organizational fields… but few have systematically followed a population of organizations over time to document organizational succession.” In a similar vein, Lomi, Larsen and Freeman (2001, 4) argued that three main questions remain currently unresolved by ecological theories: “[T]he first is: Why do organizational populations suddenly collapse after reaching a peak? The second is: Why do organizational populations oscillate after collapsing? … [The third is:] What might cause organizational populations to go extinct?” This paper represents a first attempt to address the last of these questions. To reach this goal, I have first developed three mutually exclusive hypotheses adapted from the work of Diamond (1984), and then, analyzed the entry rates of motorcycle producers in Belgium during the years included between 1900 and 1993.

Overall, the findings obtained provide evidence to advocate the internal causation of extinctions – i.e. H1c. Yet, the results confirm the classical dilemma of the density-dependence theory of evolution: it explains the growth and stability of populations' trajectories, but not their sudden decline (Carroll and Hannan, 1989; Baum, 1995). The estimates presented for density-dependence the legitimation and competition processes account for the zero founding events of the years after World War Two, but they do not provide sufficient evidence to justify the collapse of this population. Thus, while this work supports the endogenous nature of extinctions, it re-proposes the theoretical challenge of understanding why populations, instead of stabilizing, collapse. A tentative explanation, at least for this population, might be related to a structural perspective on organizational failure. As the theory suggests, organizations exist in a system of concatenated roles, in which the effects of individual failure events may propagate and affect the life chance of other organizations (Lomi and Larsen, 2001). Four main organizations molded the evolution of the Belgian motorcycle industry (Wilson, 1996) – i.e. FN, Gillet-Herstal, Minerva and Sarolea. Nonetheless, during the Fifties several important changes took place. In 1954, Sarolea and Gillet-Herstal merged with FN. In 1955, Minerva stopped producing motorcycles. Then, with the failure of the FN in 1965, the nation lost one of the "pioneer(s) in the motorcycle field and for many years the leading make in Belgium" (Tragatsch, 2000, 224). As engine represents one of the most critical (and expensive) components of a motorcycle, FN and Minerva were responsible for supplying engines to those manufacturers unable to invest in their own production. Thus, they might be considered as 'keystone actors' of this population. Evolutionary biology informs us that similar actors are especially important because of their large impact on population dynamics and stability: their loss can cause extinction to cascade throughout the system (Owen-Smith, 1987; Solé and Montoya, 2000). Therefore, the failure of Minerva and FN might have accelerated the process of decline of the Belgian population. While intriguing, more evidence is clearly needed to support a similar hypothesis.

The theoretical implications stemming from this research are at least twofold. First, the simultaneous (partial) success of H1c and failure of H1b, casts some doubts on the common definitions of competitive processes. Since Georg Simmel,[vi] the study of competition has assumed two different perspectives, namely cognitive and ecological. On the one hand, rivalry – or conflict – represents a form of competition among a limited and mutually recognized number of firms (Scherer and Ross, 1990). This definition points to a *social* dimension of the process: actors are connected by a system of social linkages and orient their action in the direction of those organizations they see as rivals. On the other, Hannan and Freeman, (1977) have widely demonstrated the presence of an *asocial* component, usually called competition. Although having different market targets, organizations compete to acquire inputs necessary to production – e.g. suppliers, work force-, increasing the degree of structural equivalence[vii] among organizations. Therefore, a different form of competition exists, independent of direct interactions among firms, and involves actors partly unknown. In literature, these two views are usually associated with the theories of industrial economics and population ecology. The former assumes that during maturity industries concentrate their production around a few powerful actors (Sutton, 1991). The latter predicts populations to adjust their vital rates in order to maintain a steady state level of density (Carroll and Hannan, 2000). None of these two theories accounts for extinction events. The present study advances the existence of different dynamics of competition than those purely economic or sociological – e.g. Diamond (iii): cascades. While several authors have recently claimed a potential cross-fertilization between the two-abovementioned theories (Boone and van Witteloostuijn, 1995; Geroski, 2001), this work opens the doors to a profound rethinking of industrial evolution.

Second, Aldrich (1999) and DiMaggio (1994) have recently questioned whether populations represent the right unit of analysis to investigate selection processes. DiMaggio alerted ecologists that choosing a population as unit of analysis implies the exclusion of multiple inter-population cross effects. Communities should be the proper target. By the same token, Aldrich noticed that that populations differ in they ability to learn, with some being faster than others. Fast learners might be said to be "more efficient[ly], or more thorough[ly] than other populations. If so, widely shared routines and competencies would be more likely to be in such a population" (1999, 338). Therefore, he advanced the idea of potential 'supra-organizational' units of selection. Similarly to organizational level processes, populations better fitting the environment would be supposed to outperform those less efficient. Yet, the analysis presented here did not find support neither for community-level selection – see H1a -, nor for historical efficiency - see H1b. On the contrary, my findings demonstrate the importance of local evolutionary processes, and provide evidence to inefficient and complex dynamics of competition.

It would be unfair not to recognize that this work suffers from at least three main limitations. The first limit is related to the newness of the research question proposed and to the exploratory nature of this work. The perspective here presented is only partial and did not account for all the other environmental factors – e.g. political, legal – that potentially have influenced the event under investigation. The second limit concerns the delineation of the social units under study. According to other studies (Hannan et al., 1995) I decided to operate the selection at national level. The collection of data to control for the diffusion of multi-national firms could improve the robustness of the findings presented. Third, competition was considered homogenous – i.e. each organization contributes equally to determining the level of competition observed -, and no information is available to control for the possible differential effects of heterogeneous competitive processes.

However imperfect, and even presenting an *ad hoc* solution to the question proposed, this paper sheds light on an under explored, but important theoretical problem, calling for a wide intellectual perspective to approach it. I pick up this difficult challenge, discussing some of the potential ways to approach it. Without any doubt more research is needed to understand the dynamics responsible for populations' extinctions.

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Table 1. Zero-inflated Poisson model of founding rates for the Belgian motorcycle industry, 1900-1993.[2]

Variables	Model1	Model2	Model3	Model4
Constant	12.289	13.972**	15.260**	25.627**
	(8.349)	(7.004)	(5.974)	(6.573)
Period1 (1900-1902)	3.969	3.946	3.918	-.605
	(2.518)	(2.510)	(2.441)	(2.458)
Period2 (1903-1908)	3.233	3.178	3.181	-1.516
	(2.309)	(2.324)	(2.196)	(2.387)
Period3 (1909-1914)	3.721*	3.711*	3.720*	1.039
	(2.179)	(2.192)	(2.042)	(2.062)
Period4 (1915-1918)	-35.775**	-33.460**	-32.301**	-33.210**
	(2.204)	(2.154)	(2.042)	(1.968)
Period5 (1919-1925)	4.015*	4.002*	3.969**	1.526
	(2.130)	(2.117)	(1.975)	(1.939)
Period6 (1926-1938)	3.066	3.225	3.218*	1.381
	(2.040)	(2.020)	(1.866)	(1.802)
Period7 (1939-1945)	.069	.103	.050	-.794
	(2.193)	(2.196)	(2.080)	(1.935)
Period8 (1946-1957)	1.619	1.862	1.704	1.796
	(1.686)	(1.678)	(1.658)	(1.403)
Rail	-.004**	-.004**	-.004**	-.006**
	(.002)	(.002)	(.001)	(.001)
GDP	-.026*	-.027**	-.030**	-.021*
	(.013)	(.012)	(.010)	(.012)
Entries$_{t-1}$	.135**	.129**	.139**	.084*
	(.037)	(.045)	(.046)	(.047)
National Industry age	.083*	.086*	.091**	-.001**
	(.047)	(.047)	(.045)	(.052)
National Density	.217**	.216**	.214**	.312**
	(.034)	(.033)	(.033)	(.124)
Neighbors Density^2 (in hundreds)	-.001			
	(.002)			
Italy Density^2 (in hundreds)		-.002		
		(.007)		
Japan Density^2 (in hundreds)			.002	
			(.086)	
National Density^2 (in hundreds)				-.966**
				(.402)
Inflated Logistic Regression				
Constant	-15.501**	-16.026**	-15.016**	-17.033**
	(.939)	(.912)	(.902)	(.577)
Post Second World War	10.379	-.681	11.564	14.563**
	(22.155)	(4.621)	(11.288)	(1.589)
Log Likelihood	-84.968	-84.994	-85.071	-79.541
$\bar{\rho}^2$	.443	.442	.442	.485

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[2] *p<.10; ** p<.05. Standard Errors in parentheses.

Figure 1. Density of Motorcycle Producers in Belgium, 1900-1993.

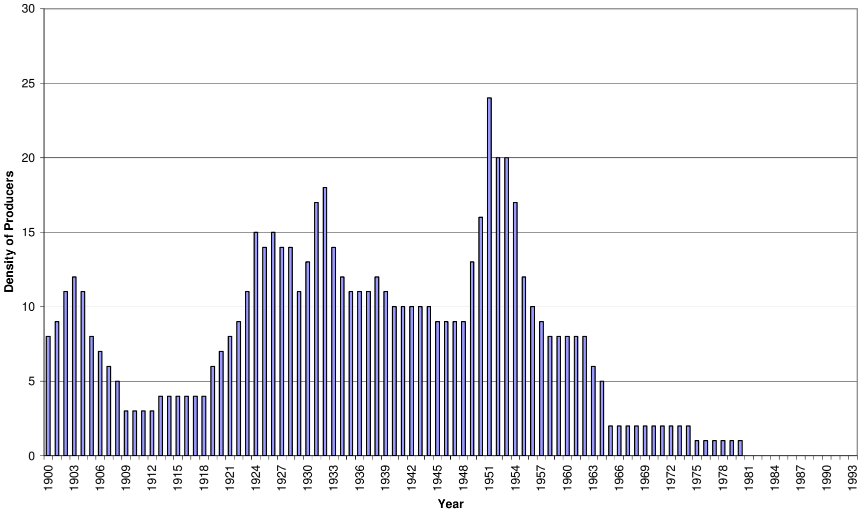

Figure 2. Births of Motorcycle Producers in Belgium, 1900-1993.

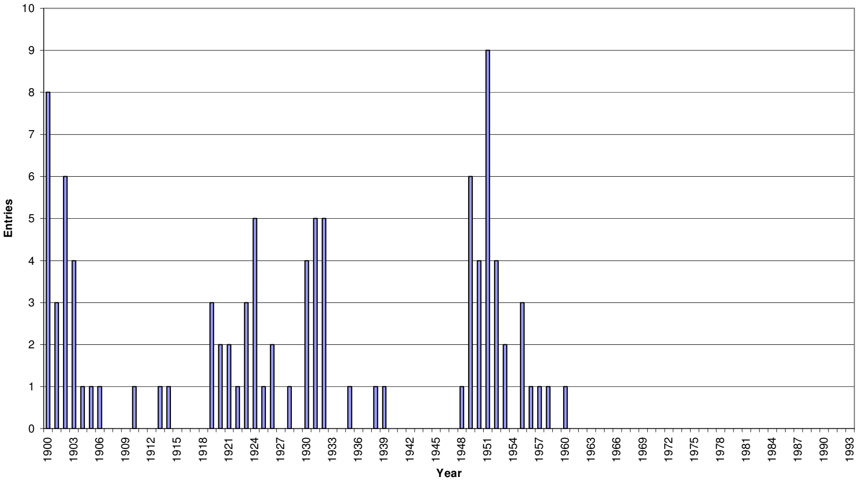

Figure 3. Estimated and effective organizational foundings in the Belgian Motorcycle industry.

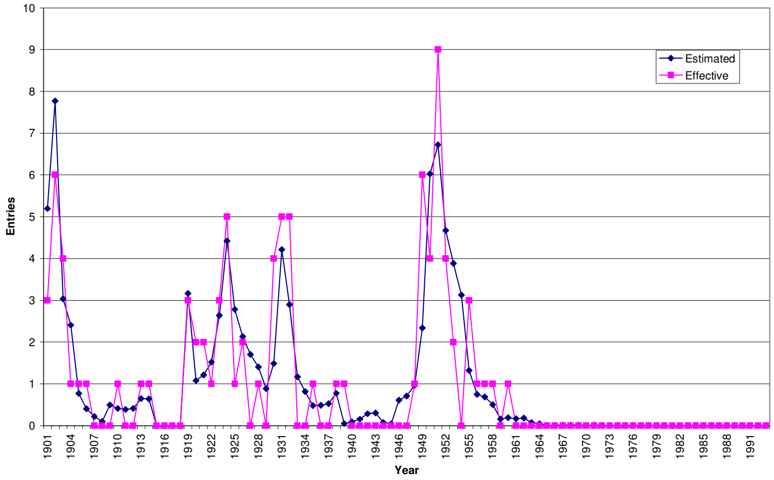

Table 2. Qualitative implications of the estimates of density dependence - Table 1 Model 4.

	N_{min}	N_{max}	λ^*	N^*	$\lambda(N_{max})$	$\lambda(N_{max})/\lambda^*$
Belgium	0	24	12.48	16	6.88	.55

Endnotes

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[i] In a racetrack economy, a large number of regions are located around a circle and transportation is possible only around the circumference of the circle (Krugman, 1997)

[ii] "Organizational populations … sometimes spans centuries of time. In these cases, environments commonly develop and change in many dramatic ways. [I]t is often difficult to find systematic data that record environmental variables in reliable and consistent fashion across the entire period. [One option is to] periodize the history and seek to estimate period-specific effects. Such periodization uses historical and institutional knowledge to identify periods where environmental conditions (of any kinds) are thought to differ significantly from each other" (Carroll and Hannan, 2000, 202).

[iii] Exploratory analysis showed that the event counts of Belgian entries were not overdispersed in the zero-inflated Poisson model. Thus, I did not invoke the negative binomial specification.

[iv] Different combinations of the linear term of density were tried. I tested processes of diffusion across multiple levels of analysis, European and national. The findings – not reported here – vouch that legitimation process in Belgium assumed a national dimension. A similar result confirms the historical importance of this country in the European production.

[v] Detailed data to support this claim, can be found at the following URL(s), for Italy and Japan respectively: http://www.ancma.it/stat_ita.asp and http://www.japanauto.com/statistics/motorcycle/mc_statistics.htm

[vi] "… the fact that two elements [in a triad] are each connected not only by a straight line – the shortest – but also by a broken line, as it were, is an enrichment from a formal-sociological standpoint" (Simmel, 1950).

[vii] Structural equivalence implies that firms occupy similar roles in the environment (Lorrain and White, 1971). Structurally equivalent organizations receive inputs from the same suppliers and their outputs meet the same needs of customers.