

Mars, Matthew M.; Bronstein, Judith

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The population ecology of undesigned systems: an analysis of the Arizona charter school system

Matthew M. Mars^{1*}  and Judith L. Bronstein²

* Correspondence: mmars@email.arizona.edu

¹Leadership and Innovation, The University of Arizona, 1110 E. South Campus Dr., Saguaro Hall 205, Tucson, AZ 85721, USA
Full list of author information is available at the end of the article

Abstract

The application of ecological concepts and principles to the study of organization design and system development is now commonplace. Population ecology is one biological perspective that has been especially influential within the organization design literature. In the current study, we illustrate for the first time how this framework can be used to reveal when and in what ways intervention is warranted within a system that, like a biological population in nature, has emerged with little to no purposeful design. Specifically, we use 20 years of data on 1,074 Arizona charter schools to illustrate how population analysis can be used to uncover the characteristics of individual organizations that have the highest ability to survive over time within systems that have been allowed to emerge with little to no purposeful design. Our findings lead us to argue how pre-intervention population analysis at the system level can influence organization-level design choices in a way that enables dynamic fit and thereby enhances the likelihood of organization survivorship and innovation over time.

Keywords: Inter-organizational dynamics, Population ecology, dynamic fit

Researchers have put immense effort into gaining a deeper understanding of the various elements that influence the structure and design of organizations and the evolution of the systems they compose. The relevant lines of inquiry are often guided by theories that originate within economics and sociology, with primary foci being system creation, growth, continuation, and performance (e.g., Borgatti and Foster 2003; Ibarra et al. 2005; Kilduff and Brass 2010; Perry-Smith and Mannucci 2017; Smangs 2006).

There are also a growing number of instances in which the study of organization design and system development incorporates principles from ecology, the field of biology that studies the interaction between species and their environment (e.g., Acs et al. 2017; Baldwin 2012; Brown and Mason 2017; Jacobides et al. 2018; Kapoor 2018; McMullen 2018; Shaw and Allen 2018). This is appealing, as ecological systems in nature are made up of hierarchies of units that grow, shrink, network, and change function over time. Multiple efforts have been made to map ecological hierarchies onto organizational structures. One approach is to use principles from population ecology

(Carrol 1984; Hannan and Freeman 1977). Within this framework, single organizations are treated as “individuals” that can vary in properties, and groups of organizations that serve a certain function are considered “populations”. An alternative framework is to consider organizational networks to be ecosystems (Mars and Bronstein 2018; Mars et al. 2012; Shaw and Allen 2018). This framework treats groups of organizations that form complex networked units in which there are within-unit and across-unit positive, neutral, and negative interactions that are influenced by variable and often unpredictable external conditions. For example, the ecosystem framework is commonly used to study value chains that enable the diffusion of innovations (Jacobides et al. 2018). Each of these approaches has value: the population-ecology approach captures both the short- and long-term dynamics of larger systems, while the ecosystems approach captures networks of interactions in the units that make up systems. The population-ecology approach has one distinct advantage for understanding organization design, however. Following Hannan and Freeman (1977), it captures the biologically accurate idea that systems are not designed to succeed or to fail, though success or failure might ultimately result from their properties. Therefore, we propose that the population-ecology approach is an ideal framework in which to consider how the founding conditions and characteristics of an unplanned system affect the design trends and survivorship patterns across the organizations that compose it.

In order to interrogate the merits of our proposition, we chose an organizational population that has emerged with little to no preemptive design: the Arizona Charter School System (ACSS). The ACSS was initiated in 1995 when the State of Arizona (AZ) established the set of policies that first allowed for the use of public funds to found and operate charter schools. The underlying intent of this policy was to improve public education through the creation of competitive, market-like alternatives to conventional school districts (Lubienski 2003). Generally, charter schools receive a standard amount of state funding for each student enrolled, but typically at a rate that is lower than what their conventional public school counterparts receive. In return, charter schools operate with relatively high autonomy, the logic being that independence promotes (if not demands) the design and implementation of innovative service models that are able to improve student learning in efficient and cost-effective ways. Thus, the charter school model treats States as arms-length investors, and charter schools as entrepreneurial ventures that aim to create value through the productive disruption of the public education systems.

School autonomy, in conjunction with vague and shifting State oversight, has allowed the ACSS to develop fairly organically, rather than according to a proactive design. This lack of design has resulted in the ACSS evolving without strategic mechanisms (e.g., diversity in school mission and models, geographic distribution) that impose top-down influence. Episodic shifts in what have been described as *laissez-faire* oversight structures that have involved remarkably little planning or foresight have also been allowed to occur (ACSA, pers. comm., November 2018; Bulkley 2001). The choices for how schools are set up have been left to the instincts of the founding entrepreneurs and designers who, over the existence of the ACSS, have had little system-level context to draw upon when making strategic decisions. New, highly diverse charter schools have been initiated each year; conversely, large numbers of them have shut their doors after some number of years of operation. Thus, the ACSS offered us the opportunity to

examine how the founding conditions and characteristics of systems that emerge and evolve with relatively little planning affect the designs and survivorship of organizations within.

In this contribution, we use principles emerging from the biological study of populations in nature to analyze a body of data specific to the ACSS, with the intent of identifying the relational ties and dynamics that influence the structure and design of both organizations and the systems they compose. In doing so, we establish a stronger understanding of the implications of such factors as initial size and growth over time on the survival of organizations (i.e., survivorship) within shared systems. We are careful to note that the units of analysis that we focus on are the charter schools that compose the ACSS, rather than on the system itself. By focusing our analysis exclusively on the schools, we are able to illustrate how the rigorous application of biological principles and analytical techniques can reveal new, complex insights into the interplay between organization structure and design and system planning and dynamism. We close the paper with a discussion of how, based on our examination of the ACSS, population analysis can inform strategic design choices at both the organization and system levels. More specifically, we propose how and when systems such as the ACSS that have emerged with little planning and coordination might benefit from a designer's hand.

Methods

As described in the Introduction, we chose the ACSS for analysis because it is a remarkably clear case of a population that originated with very little planning and overall design and that has subsequently evolved without significant interventions. It has two additional features that lend it to this analysis. First, we can pinpoint the beginning of the formal emergence of the ACSS. We are therefore able to identify and analyze trends related to the characteristics and survival of schools over the entire duration of the system's existence. Second, the ACSS is large, having grown over the past two decades to include more charter schools per capita than any other State. Specifically, there were 556 charter schools operating in AZ during the 2016-17 academic year (the last year for which complete data are available), which equated to one charter school for every 12,619 residents (Arizona Charter School Association, 2017; United States Census Bureau 2018). Currently, charter schools make up 30% of all public schools in AZ and serve 17% of the total statewide public school enrollments (Arizona Charter School Association, 2020).

We assembled a unique longitudinal dataset that begins in 1996 and that currently extends through 2017. We accessed the data in partnership with the AZ Charter School Association (ACSA) and the AZ Department of Education (ADE). The ACSA is a non-profit organization whose mission is to foster autonomy, equity, and quality across the ACSS (Arizona Charter School Association, 2018). We note that the ACSA has no formal authority over statewide charter school policies, which is consistent with the general lack of formal and consistent design at the system level. The database consists of nearly 10,000 lines of data (one line of data per school per year of its existence) and spans 18 variables. Here, we primarily make use of 1,074 lines of the master database, with each line summarizing data for each school across its 'lifetime'. The subset of variables utilized in the analyses include (1) the year a school opened, (2) whether that school was still in operation at the end of 2017, (3) the year it closed if it is no longer

in operation, (4) the grade levels served in its most recent year of operation, (5) student enrollment in the first year of its operation, and (6) school mission. The first three variables address the lifespan of each school, while the last three variables capture the basic structure and design features of each school. A charter school mission is “defined by norms and ideas associated with educational professionalism, provision of social services, and grassroots visions tied to community and parental involvement as well as local economic development” (Henig et al. 2005, p. 489). The AZ State Board for Charter Schools (Arizona State Board for Charter Schools, 2019a) uses 22 mission-types to characterize charter schools. These are listed in Table 1. Examples of the more prominent mission-types are College Preparatory, Math and Science/STEM Foci, and At-Risk Student Population.

Although we have aimed for completeness of data, ACSS data managers have not been able to locate certain pieces of information. In particular, recordkeeping, especially for schools no longer in operation, has been sporadic due to several shifts in state agency oversight mechanisms and responsibilities. Such inconsistencies point to how the ACSS has emerged and evolved in unplanned ways. In November 2018, we conducted a day-long, in-person focus group with a panel of experts from the ACSA, ADE, and several larger AZ charter schools. This exercise confirmed the validity of the database, as well as guided us in its continuous refinement and expansion.

Table 1 AZ Charter School Mission Types used by the AZ State Board for Charter Schools (2019a)

Mission-Type

Alternative/At Risk
 Back to Basics
 Blended Learning
 Cambridge/American College Teaching Quality Core
 College Preparatory
 Computer-based
 Core Knowledge
 Dual Language
 Equine/Agricultural Studies
 Expeditionary Learning
 Extended Day/Year
 Fine Arts
 International Baccalaureate
 Math and Science/STEM
 Montessori
 Multi-age
 Multiple Intelligences
 Online/Virtual
 Dropout Recovery
 Project-based
 Special Populations
 Traditional

General charter school population descriptors

Our initial step to describing the ACSS as a whole was to first examine the sizes of 1,074 schools; schools make up the “individuals” in the charter school “population” (sensu Hannan and Freeman 1977). Recalling that there are missing data for some schools, portions of our analysis include fewer than 1,074 schools. We make note of the exact number of schools included in each of the analyses that follow. Taking into consideration the recommendations of AZ charter school experts, we defined initial school size as student enrollment, averaged across all school days of the year, for the first year of a school’s operation.

Next, we explored the distribution of two traits of schools within this population; in ecological terms, these traits could be considered descriptors of their “niches”. First, we looked at the frequency of schools represented by different grade levels in the most recent year of operation (2017 for currently operating schools, the last year of operation for those no longer operating; $n = 1,051$ schools). Forty-six different grade ranges were identified in the database (i.e., kindergarten-only schools, K-1 schools, K-2 schools, K-3 schools, etc.). In order to illuminate general patterns, we collapsed the data into the following six mutually exclusive categories: *Elementary* (K-6, inclusive of smaller subsets); *Elementary-Middle* (including K-6 or a subset of it, plus 7-8 or a subset of it); *Middle-High* (including 7-8 plus 9-12 or a subset of it); *High* (including 9-12 or a subset of it); *Multi-Grade* (including a subset of K-12 that cuts across Elementary, Middle, and High; e.g., 3-10); and *All Grades* (K-12).

The second niche trait that we considered was the charter school’s mission. We examined the frequency of currently operating schools pursuing different missions ($n = 481$ schools). For schools initiated since 2013, usually one but occasionally as many as four missions are listed for each school on the Arizona State Board for Charter Schools (2019a) website. For the purposes of this analysis, we chose, with guidance from ACSA staff, the most general mission (e.g., if a school is listed as both ‘College Prep’ and ‘International Baccalaureate’, we classified its mission as the former). For schools initiated prior to 2013, only brief narratives of their goals were requested by the ADE, and these are also provided on the Arizona State Board for Charter Schools (2019a) website. We read each narrative and used it to characterize the school using one of the 22 missions listed in Table 1. This was generally straightforward. As an example, one school describes itself as “a high-quality college-prep school that prepares Tucson-area students for success in school, college, and 21st century careers.” Based on this description, we coded it as College Preparatory.

Dynamics of the charter school population

As a first step in documenting the population dynamics of the ACSS system, we explored four dynamic phenomena: (1) population growth, using the number of schools in operation per year from the inception of the ACSS through 2017; (2) the number of new schools initiated each year; (3) the number of schools that ceased operation each year; and (4) the survivorship curve for the ACSS as a whole. A critical tool in ecology, medicine, and numerous other fields (Liu 2012), survival analysis quantifies average, median, and maximum lifespan. Further, it reveals whether most “newborn” individuals survive to an old age or die at a young age, or if survival is independent of age. It is

ideal for quantitatively comparing groups. This method can equally well be used to describe any population, human or otherwise, in which large numbers of individuals are founded and go on to have quantifiable lifespans. In the current study, we applied survival analysis to describe the fates of charter schools initiated from 1996 through 2017. We estimated survival functions with the Kaplan-Meier estimator and log-rank tests, using the ‘survival’ package in R (Therneau 2015, R Core Team 2018).

Predictability of charter school survival

The characteristics of the individuals (i.e., single charter schools) that have been able to survive within the ACSS population have been surprisingly underexplored. Accordingly, we chose to explore the potential of biologically inspired analysis to reveal survivorship patterns across the ACSS. As a first step towards this goal and to further document the value of such patterns, we explore three ‘niche traits’ that are likely predictors of school survivorship.

First, we used survival analysis to test whether an individual school’s ability to survive within the ACSS population is a function of the identity of its charter holder. A charter school holder is the entity that is accountable to the contract that enables the operation of schools (Arizona State Board for Charter Schools, 2019b). A holder can be a stand-alone school or a group that oversees a network of schools. Interestingly, public school districts were able to act as charter holders for a majority of the time that the ACSS has been in existence, with a notable increase in the number of such charter holders occurring in 2014. In 2016, however, policy reform was passed that ended this option, under the logic that such arrangements failed to reach the underlying intentions for school choice and market-based increases in school performance (ACSA, pers. comm., November Arizona Charter School Association, 2018). We tested whether the ‘failed experiment’ of district-charter conversions could be detected by survival analysis. To do this, we compared two survival curves, one consisting of the 207 charter schools that had public school districts as the charter holder, the other consisting of the 861 schools with other charter holder-types. We tested the hypothesis that the former group would show statistically lower survival. This analysis serves as a proof of concept for the use of survival analysis to illuminate survivorship trends across the ACSS.

Second, we examined whether school enrollment at the time of its founding (i.e., the size of individuals within the population, a trait likely to affect survivorship ability of organizations; Hannan and Freeman 1977) predicts its subsequent lifespan, a pattern that has not previously been investigated. For the purposes of this analysis, we divided schools into four categories: *Small* (below 50 students), *Medium-Small* (50-100), *Medium-Large* (101-250), and *Large* (above 250). We tested for statistical differences in survivorship of the four enrollment size categories using log-rank tests. We then calculated the probability that schools in each enrollment size category would be able to survive for five, 10, and 15 years.

Finally, we examined whether grade range predicts a school’s lifespan, another pattern that has not previously been investigated. We used the six grade-range categories defined above for this purpose. We tested for statistical differences in the survival curves of these grade-range categories using log-rank tests. We then calculated the probability that schools in each category would be able to survive for five, 10, and 15 years.

Results

General charter school population descriptors

At the time of founding, AZ charter schools have ranged from 0.25 to 1439.14 students, with an average across schools of 163 students and a median of 75 students (see Fig. 1). As shown in Fig. 2, charter schools most commonly are composed of elementary and middle grades (usually K-8), elementary grades (usually K-6), or high school (usually 9-12). The most commonly cited of the 22 charter school missions listed in Table 1 are College Preparatory, Alternative/At Risk, and Traditional; together, these missions are represented in approximately 65% of currently active charter schools to characterize their missions (see Fig. 3).

Dynamics of the charter school population

School openings are illustrated in Fig. 4. Evident are two waves of school openings, one peaking around 2000 (the fourth year of the ACSS) and another beginning in 2012. School openings were far more frequent during the first ten years of the ACSS's existence than they have been subsequently, with the exception of a marked peak in 2014, when the ASBCS converted many district schools to charter schools. School closings are shown in Fig. 5. These have been sporadic throughout the history of the ACSS. There is a marked peak, however, in 2016, when the district schools that had been shifted to charter status in 2014 were returned to district status.

Just as in a biological population whose size at any point is set by a balance of births and deaths, population size of the ACSS at any point is set by school openings and closings. As shown in Fig. 6, the total size the charter school population (defined here as number of schools in operation each year) grew rapidly for about its first seven years;

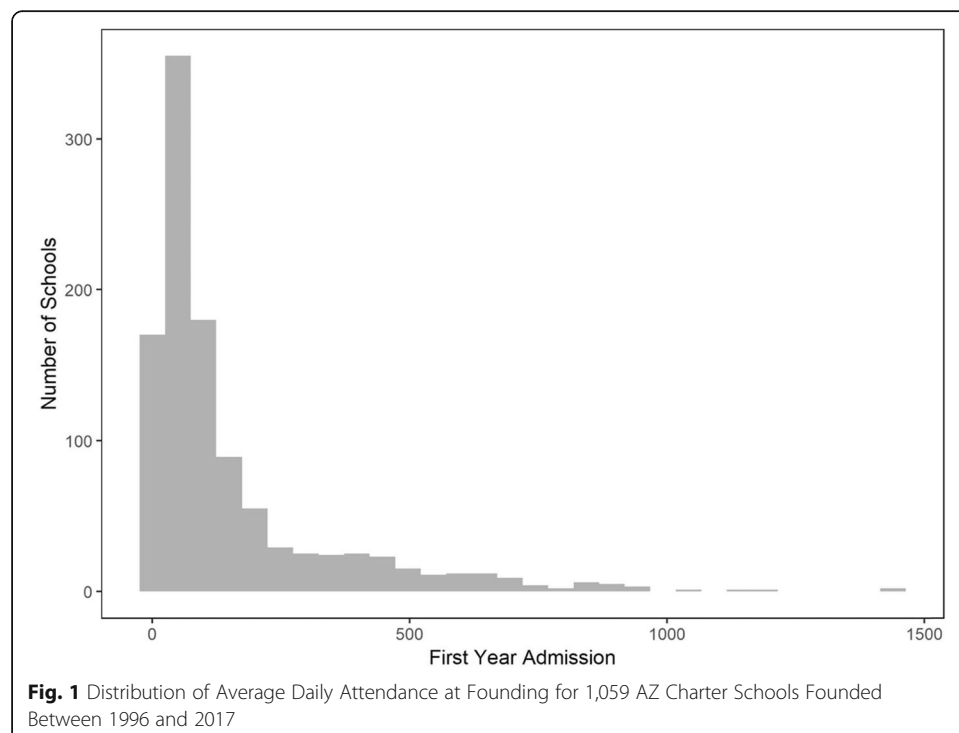
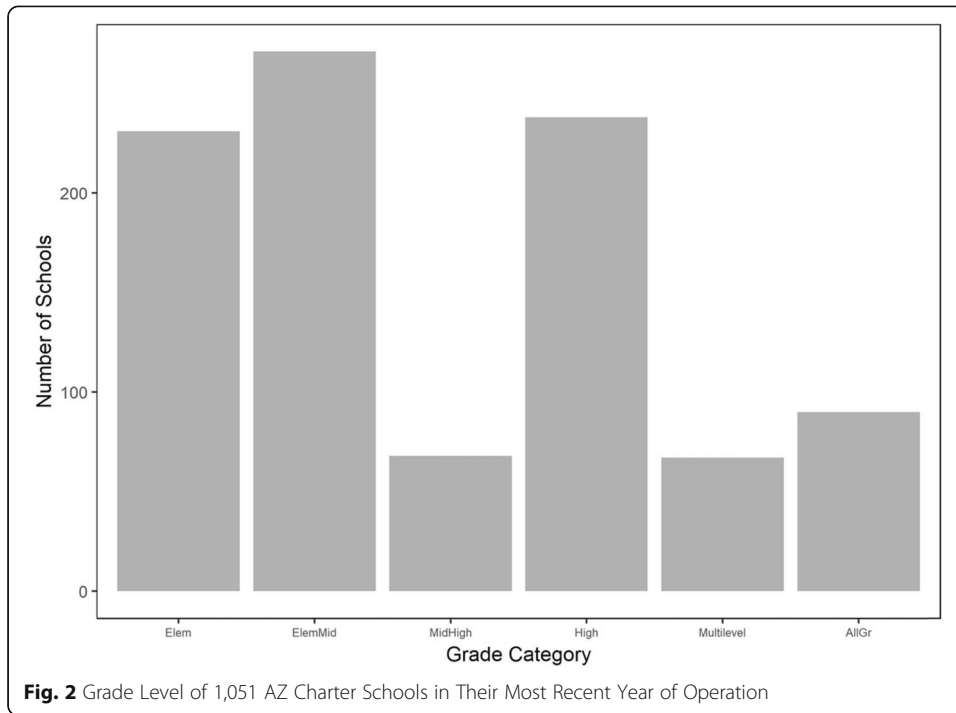
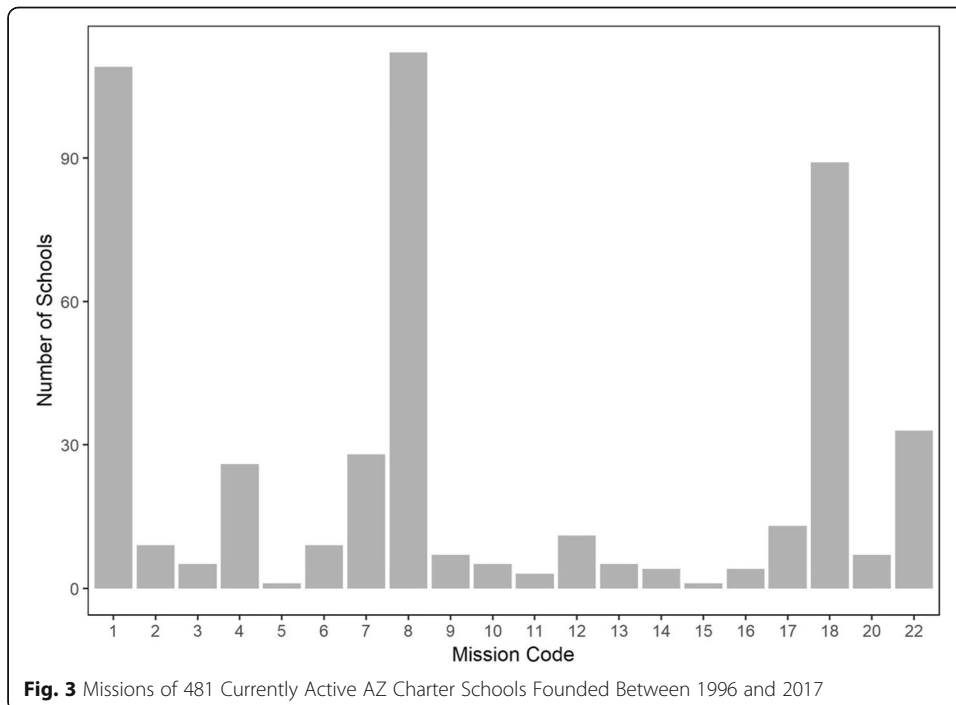


Fig. 1 Distribution of Average Daily Attendance at Founding for 1,059 AZ Charter Schools Founded Between 1996 and 2017



since then, it has fluctuated at around 500 active schools per year. Two deviations from this general pattern can be seen: a small decrease in total charter school numbers in 2007-2008, corresponding with the U.S. economic downturn, and a sharp peak and subsequent fall in 2014-2016, corresponding again with the interval (see Figs. 4 and 5) in which a large set of district schools were converted to charter schools and then back again.



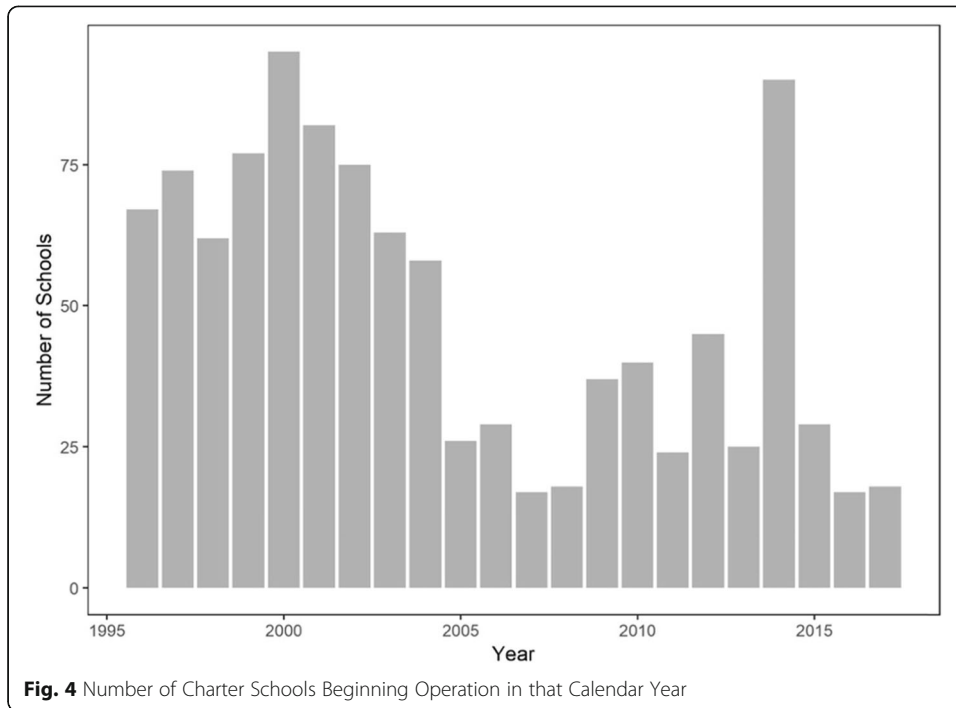
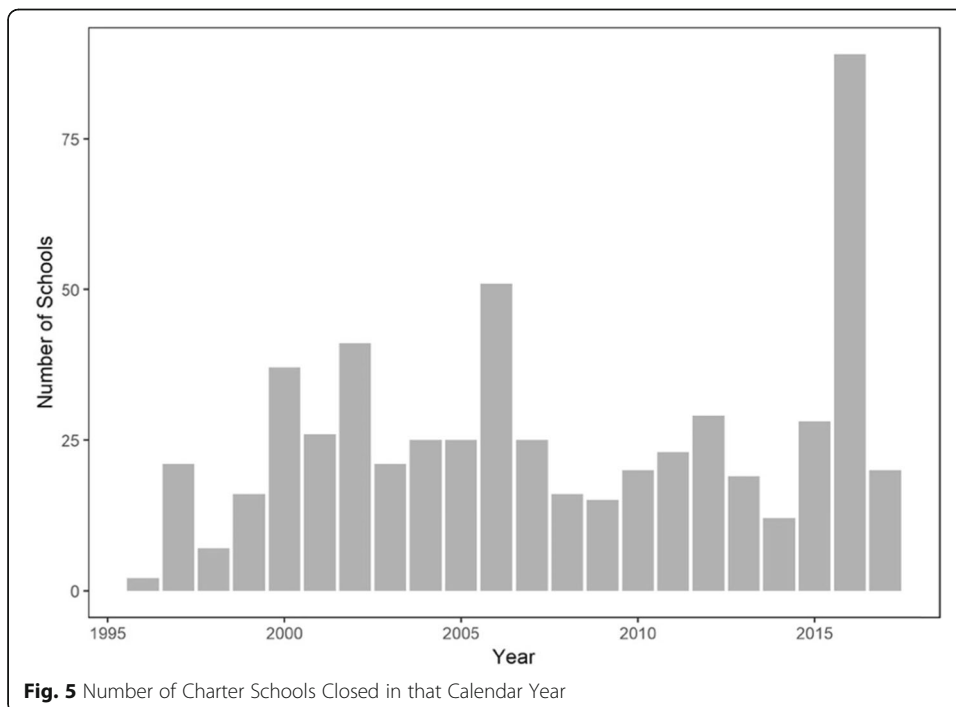
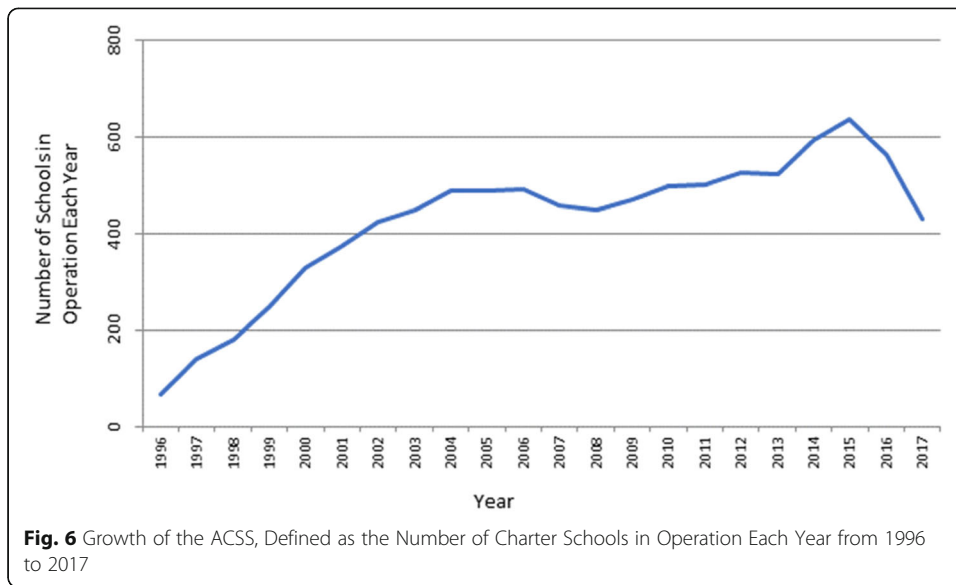


Figure 7 illustrates the survival curve for the ACSS as a whole. Median survival time for charter schools has been 12 years, with a 95% confidence interval of 10-14 years. As of 2017, maximum possible lifespan was 22 years, the age of the ACSS as a whole; that is, some schools founded in the first year of the AZ charter school movement were still in operation in 2017, and are likely to live longer. Overall, this survival curve indicates that there is a progressive loss of newly founded charter schools, such that after three

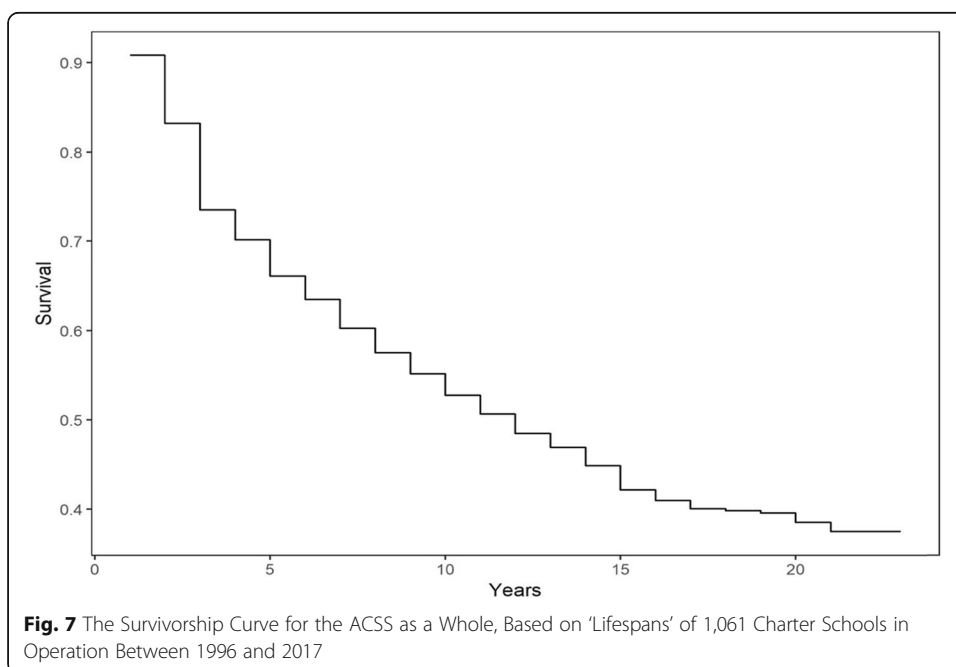




years in operation, only about 72% of schools are still “alive”. This is followed by a slower rate of “mortality”, until a school has survived about 15 years, after which it has a high probability of further survival.

Predictability of charter school

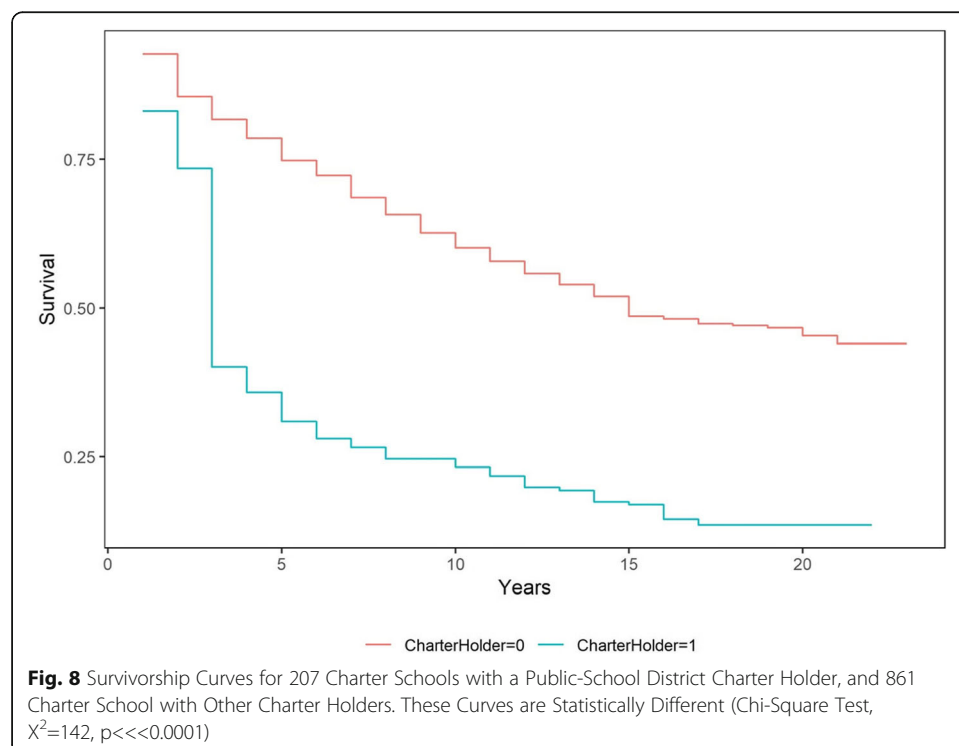
Survival analysis can be used to statistically test hypothesized factors controlling differences in lifespans between groups. We tested whether it could detect the known ‘experiment’ in which large numbers of district schools were converted to charter schools and then back again. Survival functions for 207 charter schools with a public-school

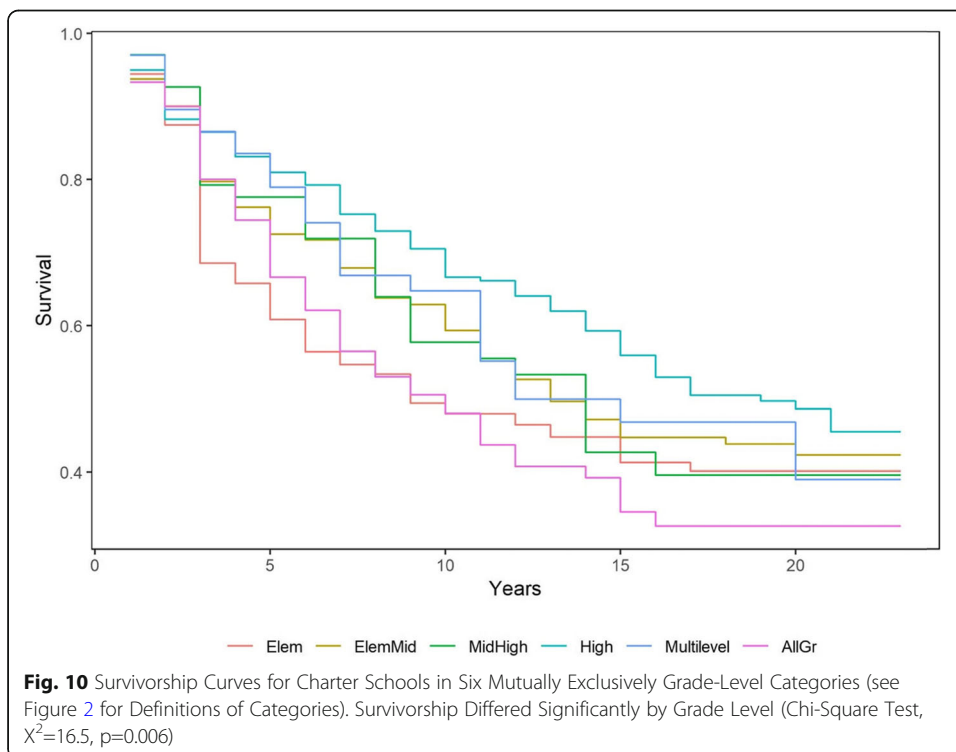
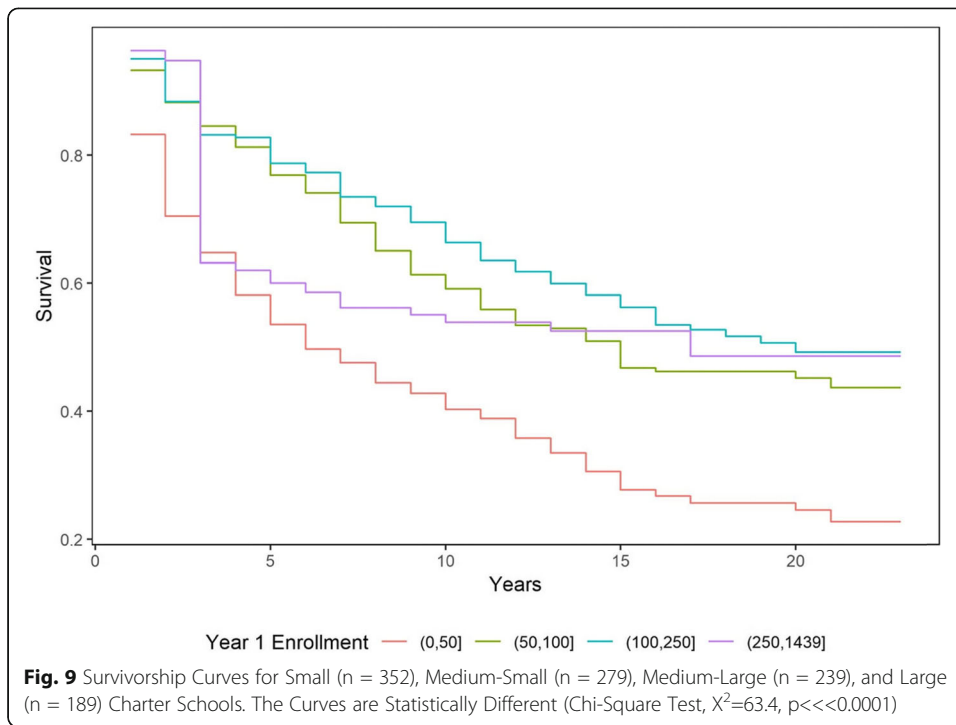


district charter holder and 861 charter school with other charter holder-types are illustrated in Fig. 8. These relationships are indeed dramatically different (log-rank test, $X^2=142$, $p<<<0.0001$). The survivorship difference appears in the very early years of a charter school's existence: estimated survival of district-run schools at three years was 40% (95% confidence interval 34%-47%), whereas non-district-run charters had over 80% survival to the same age. Once beyond the third year, survival functions appear to be similar.

Although the survivorship difference illustrated in Fig. 8 was one already known to those who administer the ACSS, it suggests that similar analyses can be used to identify survivorship patterns that had previously not been recognized. We tested for the existence of two previously unexamined patterns. We first looked at whether initial enrollment (i.e., the "size" of an individual) predicted the lifespan of that individual (i.e., school). We found strong statistical evidence that it did (log-rank test, $X^2=63.4$, $p<<<0.0001$). Survival curves for small ($n = 352$), medium-small ($n = 279$), medium-large ($n = 239$), and large ($n = 189$) charter schools are shown in Fig. 9. It evident from this figure that the smallest size class (schools enrolling fewer than 50 students at the time of founding) showed notably lower survival rates over time compared to their large counterparts.

Lastly, we looked at whether grade level, another niche characteristic, predicted charter school lifespan. Survival curves for six grade-level groups are shown in Fig. 10. Survivorship differed by grade level (log-rank test, $X^2=16.5$, $p=0.006$), although the differences are not as striking as those associated with charter holder-type (see Fig. 8) or enrollment (see Fig. 9). Survival has been lowest for schools covering the full K-12 grade range (71% probability of survival for 15 years) and highest for high schools (91% probability of survival for 15 years). Elementary schools appear to have a relatively high failure rate in their early years, but those that survive five years are subsequently long-lived.





Discussion and conclusion

Our findings have revealed three salient trends that together characterize the effects the mostly unplanned emergence and evolution of the ACSS has had on the designs and survivorship patterns of AZ charter schools. First, the data show a positive association between the narrowness of grade levels offered by an individual school and its survival. Second, schools with smaller initial enrollment sizes have notably shorter lifespans. Third, mission does not appear to have a marked influence on school survivorship. In this closing section, we draw on these three trends to argue how pre-intervention population analysis can influence design choices in ways that enhance the likelihood of organization survival, as well as innovation at the both the organization and system levels.

Organizational scientists, and more generally management and strategy researchers, are predominantly focused on the design challenges and opportunities that confront managers, executives, and entrepreneurs within organizations. The resulting literature treats with relevant depth how design choices are made relevant to a wide range of endogenous and exogenous factors, which are often referred to as environmental contingencies (Donaldson 2001; Miles and Snow 1984). Attention has mostly remained on how designers consider and respond to such environmental factors when setting up and refining structures and models (e.g., operational protocols, technological platforms) that are aimed at maximizing the performance of individual organizations. Here, our unique contribution is the illustration of how biological analysis of a population of organizations (e.g., ACSS) can be used to uncover otherwise enigmatic survival patterns that occur across systems that emerge and evolve in relatively unplanned ways. We are careful to note that our focus has been on survival patterns at the population level, rather than on the designs and dynamics of individual organizations, with the latter being far more commonly considered in the organization design literature (e.g., Fichman and Levinthal 1991). We argue such identification of survival patterns can reveal the need for and guide the implementation of individual and population design interventions.

The lifespan of organizations is often thought to be determined by a natural selection process that favors those with the strongest “fit” to internal and external contingencies (Aldrich et al. 1984). Miles and Snow (1984) succinctly define fit as “a process as well as a state – a dynamic search that seeks to align the organization with its environment and to arrange resources internally in support of that alignment” (p. 11). Accordingly, the internal alignment of an organization’s structure, processes, and elected strategies, as well as its alignment with external contingencies, heavily influences its overall performance, competitiveness, and likelihood of long-term survival (Burton et al. 2004; Donaldson 2001). The fit of an organization, which is directly associated with its design, is revealed over time relevant to its capacity to thrive during periods of equilibrium and survive through and recover from episodic disturbances (Joseph 2018; Nissen 2014).

Fit was originally conceptualized as an end-state destination that organizations seek to reach and sustain until some internal or external event engages the process anew (Venkatraman 1989). Yet, just as organizations and organizational environments are now seen as being dynamic, so too is the concept of fit (Nissen 2014; Sinha and Van de Ven 2005; Zajac et al. 2000). Notably, Nissen and Burton (2011) propose a dynamic model of fit that is anchored in two primary concepts: *stability* and *maneuverability*. Stability refers to the capacity of organizations to fluctuate on and off a general

trajectory that is itself more dynamic than static. This dynamic state also underpins the concept of maneuverability, which refers to the organizational capacity to shift from one trajectory to another as constraints continually arise. In order to remain in a state of fit, designers must continually navigate between processes directed at stability and those that involve maneuverability.

In our study, the lack of planning and structure at the system level provided charter schools with a high degree of autonomy in how to pursue, achieve, and sustain fit. Survivorship patterns indicate that the path to the stability needed for initial fit is mostly tied to reaching relatively large enrollments within a narrow range of grades. On one hand, such fit is conducive to the survival of individual schools. On the other hand, the vision of the AZ charter school movement to productively disrupt public education by offering students and parents with innovative alternatives has not been translated to the designs and structures of the schools themselves. This finding indicates that system level interventions aimed at more purposefully inducing innovation at the school level is warranted. To be successful, such interventions would need to set up new external contingencies that would require schools seeking both internal and external fit to maneuver in innovative ways that align with and are adequately supported by the intended vision of the ACSS. We now return to the biological perspective to push this proposition further.

Organizations that achieve and sustain fit are by and large intentionally designed. This creates a dilemma when it comes to utilizing biological concepts and principles to study organization design phenomena. Critically, in nature, individuals, populations, species, and ecosystems are not designed – instead they unintentionally emerge, evolve, and perish. Thus, the use of biological concepts and principles to interpret organizational phenomena cannot start from an assumption of intentional design. We therefore argue that analyzing the ecology of a population *in the absence of* intentional design, as we have done here with the ACSS, can help designers within organizations identify when interventions are needed to achieve and/or sustain a fit state. For instance, our results indicate that it would be prudent for entrepreneurs launching new charter schools to begin with a limited grade range (e.g., grades 9-12 rather than grades K-12). These same entrepreneurs would also be advised not to set initial enrollment targets that are too low (i.e., members, *sensu* Hannan and Freeman 1977), as suggested by the survivorship curve presented in Fig. 9. Interestingly, both of these insights are counterintuitive. Presumably, from a market standpoint, the more grades a school offers, the more students it will likely attract. Yet, population-level patterns clearly show that narrowing the range of grades an individual school offers increases the likelihood of survival, at least in its early years. Insights such as these are likely to elude entrepreneurs and designers without the type of population analysis that we have performed here – thereby increasing the likelihood that ineffective or, worse yet, counterproductive design choices will be made in terms of organization level performance and survivability, as well as system level impact.

Studying how survival patterns emerge and evolve over time across a population has the promise to lend valuable, but otherwise hidden insights to designers who aim to reach and sustain dynamic fit within their respective organizations. For example, designers within early-stage entrepreneurial organizations such as AZ charter schools can more purposefully set up their organizations in ways that enhance the likelihood of

dynamic fit and thereby promote survival during the highly volatile early years of existence. Conversely, recognizing which design features are most directly tied to survival can direct designers to other features that may be more conducive to innovation. For instance, AZ charter school entrepreneurs may decide to experiment with innovations relevant to mission rather than enrollment size and grade range.

Yet, we also draw attention to how the examination of survival patterns over time across a population can inform system level decisions that create and sustain conditions that are more conducive to innovative design choices at the organization level. Indeed, organizational scientists have begun to pay greater attention to how design choices, and strategic choices more generally, made within organizations both influence and are influenced by the dynamics across shared systems (Sarasvathy et al. 2008; Sinha and Van de Ven 2005). For example, Gavetti et al. (2017), inspired in part by the evolutionary biology concept of niche construction, theorize how, over time, the strategic design choices that organizations make to enhance their competitiveness alter the dynamics of the sectors in which they operate. Consequently, such alterations make the competitive gains enjoyed by individual organizations shorter lived. While such design choices are purposeful at the individual organization level, the shaping of the competitive dynamics at the population level is far less intentional.

By being mostly unplanned, the ACSS has provided little to no clear overarching foundation for the school entrepreneurs to strategically design around. Likewise, there are few measures in place to encourage the development of a robust, nested system (see Mars et al. 2012) composed of a wide and varied range of schools. Instead, the entrepreneurs have been left to craft, based on what they know and can control, designs that they believe will have the greatest likelihood of ensuring survival and achieving top performance, i.e., a state of fit (see Donaldson and Joffe 2014). Our findings suggest that without planned structures in place at the system level that evoke innovation, the entrepreneurs have come to rely almost entirely on their own knowledge and backgrounds in education, as well as the variables they can reasonably expect to control when making their design choices. In particular, grade ranges are presumptively narrowed to allow for the application of specialized knowledge and precise instructional approaches that directly align with the shared characteristics and learning needs of students within a confined developmental stage (ACSA, pers. comm., November Arizona Charter School Association, 2018). Enrollments are then scaled within this defined space in pursuit of the critical mass needed for survival. In this regard, enrollment numbers grow vertically within a specialized, highly crafted space rather than horizontally across a more diverse terrain. Subsequently, the ACSS has evolved in a largely homogenous way that reflects more of a conventional public school system composed of relatively large schools that conform to conventional grade structures rather than as a disruptive alternative made up of innovative models. Overall, our findings suggest that the school entrepreneurs have pursued fit through design choices that reflect features that are most familiar to them as educators. Consequently, the ACSS as a whole has evolved into an educational system that is more similar to than disruptive of the very public education system it was intended to displace.

The aforesaid explanation is consistent with previous studies that show a reciprocal dynamic between systems (and environments) and organizations that involves the former both shaping and being shaped by the latter (Santos and Eisenhardt 2009;

Sarasvathy et al. 2008; Weick 1979). It also leads us to argue that identifying natural survival patterns across a population is a promising approach to eliciting more purposeful design choices specific to the population itself. For instance, if diversity of school size and novel grade ranges are desirable traits of the AZ charter school population, the ACSA and/or the ADE should consider ACSS-level design interventions aimed at increasing the survival rates of schools with smaller enrollment sizes and/or wider grade offerings. In this regard, population analysis, when conducted at the pre-invention phase according to the fundamentals of biology, can influence more purposeful and impactful design choices at the organization level. Likewise, such analysis can also inform system level policy making in ways that more purposefully foster organization level designs that are conducive to intended outcomes. This recommendation is especially promising for entrepreneurial initiatives in the public sector, such as the ACSS, where progress is often stifled by system-level governance models that are poorly structured and inadequately equipped to foster and support innovation (Cinar et al. 2019; Levine and Wilson 2013; Mergel 2018).

Regarding dynamic fit (Nissen 2014; Nissen and Burton 2011), more purposeful interventions at the system level would better equip organization-level designers to more quickly achieve states of stability and establish the nimbleness needed to effectively maneuver along with shifts in external contingencies. The capacity of these designers to make choices that spawn innovation would also be enhanced as system level planning and certainty increased. In particular, the likelihood of organizational failure (or death, in biological terms) due to too much or too little innovation would be reduced as otherwise undetected environmental factors are proactively addressed. Concurrently, overall impact would likely increase with organization-level designers being better equipped to align organizational structures and strategies with system level agendas and evolving conditions and priorities. This synergy between innovative design choices at the organization level and purposeful interventions at the system level is especially important considering the dynamism that characterizes most organizational systems and environments.

To our knowledge, we are the first to use population analysis to illustrate the underlying synergy between purposeful design interventions at both the individual and population levels and its influence on both organizational survival and innovation via dynamic fit. The insights we have generated contribute to a growing literature that directly considers the role of intentional policy making at the system level in coordinating and shaping more innovative and impactful designs at the organization level (see, for example, Kedenic 2017; Levitt and Eriksson 2016). We began this paper by underscoring the absence of design in nature, a fundamental limitation to applying biological concepts and principles to organizational phenomena and, more specifically, organization design. We have not abandoned our own cautionary note. Instead, we have shown the promise of initiating design strategies with population ecology analysis in order to reveal otherwise obscure, naturally occurring survivorship patterns over time and across systems. The ecological methods that we have used should be routinely deployed to continually track survivorship patterns over the lifespan of a population. Just as conservation ecologists conduct analysis of populations in nature prior to recommending human interventions to halt declines, so too should organization designers and system planners seek out naturally occurring survivorship patterns prior to making design choices and enacting systemic interventions.

Abbreviations

ACSA: Arizona Charter School Association; ACSS: Arizona charter school system; ADE: Arizona Department of Education; ASBCS: Arizona State Board for Charter Schools; AZ: Arizona

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Authors' contributions

Matthew M. Mars and Judith Bronstein contributed equally to this work. The author(s) read and approved the final manuscript.

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Availability of data and materials

We assembled a unique longitudinal dataset that begins in 1996 and that currently extends through 2017. We accessed and compiled the data in partnership with the Arizona Charter School Association (ACSA) and the Arizona Department of Education (ADE).

Competing interests

We have no competing interests.

Author details

¹Leadership and Innovation, The University of Arizona, 1110 E. South Campus Dr., Saguaro Hall 205, Tucson, AZ 85721, USA. ²University Distinguished Professor, Ecology and Evolutionary Biology, The University of Arizona, 1041 E. Lowell St., Biosciences West 418, Tucson, AZ 85721, USA.

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