Strategic resource allocation in entrepreneurial businesses during epidemic growth periods

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ABSTRACT

To entrepreneurial businesses, epidemic growth dynamics can be an attractive and a daunting proposition at the same time. Rapid, widespread growth of sales numbers is certainly attractive, but it can easily turn into a hazard, when the business becomes overwhelmed by demand, mistimes investment decisions, loses orders and hurts its reputation. Surprisingly, research that guides entrepreneurial businesses in allocating their constrained resources during periods of epidemic growth is scarce. To that end, the author reviews extant literature to extract the pertinent process characteristics of epidemic growth in a business context, and combines them with archival case evidence to inform entrepreneurial ventures in the strategic resource allocation during epidemic growth periods. Overall, the results from this study indicate that a better understanding of epidemic dynamics will benefit investment and planning decisions. More specifically, the findings suggest that entrepreneurial, resource-constrained businesses can maximize the benefits during epidemic growth periods, if they allocate their Marketing and Operations resources with focus and in accordance with the stages of the epidemic growth process.

Key words: strategic resource allocation, epidemic growth periods

INTRODUCTION

Epidemic (rapid, widespread) growth can be an attractive or a daunting idea - and sometimes, both. Growth processes that start at the micro-level, with one or a few participants, and rapidly accelerate to become a phenomenon at the macro-level are daunting, when they happen in conjunction with a disease. In such cases, an understanding of the epidemic growth process is a critical element of prevention or containment of disease proliferation. For that reason, there are numerous studies on the epidemic dynamics of diseases, such as pandemic influenza (Bobashev et al, 2007), HIV (Goodreau et al, 2012) or eating disorders (Gordon, 2000). By contrast, epidemic growth can be an attractive prospect in other contexts, such as business or politics. In a recent case, sales for Breathometer, a smartphone compatible product that measures breath-alcohol levels grew from $140k to $1M in just 3months (Pai, 2014). On the other hand, epidemic growth can become a hazard, when businesses become overwhelmed by demand, lose orders and hurts their reputation. Breathometer, for instance, incurred significant shipment delays in 2014[1], damaging their customer satisfaction[2] and, by extension, their reputation. Accordingly, a better understanding of epidemic growth dynamics has significant value for small, resource-constraint enterprises, such as Breathometer, who do not have much room for misallocation of capacity or financial resources (Murphy and Long, 2009). There is ample work in business literature about how epidemic growth begins and proliferates (see Lescovec et al, 2007; Hinz et al, 2012). Surprisingly, there is little work that guides entrepreneurial businesses in allocating their constrained resources during periods of epidemic growth. In this paper, the author examines process characteristics of epidemic growth and combine them with case evidence to inform strategic resource allocation in entrepreneurial, resource-constrained businesses during epidemic growth periods.

METHODOLOGY AND ORGANIZATION OF THE ARTICLE

To meet the goal of this study, the author employs a process-tracing approach (George and Bennet, 2005). Specifically, the author first extracts the pertinent process characteristics of epidemic growth in a business context from extant literature and then maps case evidence onto the process to identify effective practices for strategic resource allocation. The sources of evidence include archival data about recent business cases of epidemic growth. In addition, the author conducted semi-structured interviews to generate more detailed insight into the case of single-use Biopharmaceutical processing systems (SUBPS)[3]. Interviewees included a product manager at a provider of SUBPS, a technology manager at a Biopharmaceutical manufacturer and an engineering manager at a component supplier for SUBPS.

This article continues with a review of prevalent analytical perspectives on epidemic growth processes. Specifically, the author extracts the key parameters of infection and proliferation from disease epidemiology and identifies the relevant process stages from CCPD perspective. The discussion of process stages includes selected case vignettes that illustrate the applicability of a CCPD perspective and identify effective resource allocation practices. Finally,

[1] https://www.breathometer.com/2014/04/15/first-quarter-2014-went-as-planned-for-the-most-part/

[2] Customers reported shipment delays, resulting wait times of 4-12 months and dissatisfaction in a survey of 154 online customer reviews from Q4 in 2014

[3] http://www.drug-dev.com/Main/Back-Issues/SINGLEUSE-MARKET-Rise-of-SingleUse-Technologies-Sy-1022.aspx

the author summarizes the findings about process characteristics and case evidence to inform the strategic resource-allocation process during period of epidemic growth.

PROCESS CHARACTERISTICS OF EPIDEMIC GROWTH: DISEASE EPIDEMIOLOGY AND COMPLEX CAUSAL PATH DEPENDENCE

The subject of epidemic growth processes is informed by a variety of perspectives. In this section, the author will focus on addressing the contributions and limitations of disease epidemiology and complex causal path dependency (CCPD), as they apply to the management of epidemic growth in a business context.

Disease epidemiology perspectives of epidemic growth processes

Epidemic growth processes have been of interest for scientists, who investigate the spread of infectious diseases, for a considerable time. Examples of infectious diseases that follow an epidemic growth pattern include the plague in medieval Europe, a potential outbreak of a Pandemic Influenza, which is overdue to re-occur ever since the 1960's, the worldwide spread of HIV since the 1980's or, most recently the occurrences of the Ebola and Zika virus'. Epidemic diseases are characterized by spread rates of great reach and rapid acceleration. To explain the growth dynamics of an epidemic, disease epidemiology generated the classic SIR model (see Murray et al, 1989), which divides the population into classes of 'susceptible' (S), 'infective' (I) and 'removed' (R) (Figure 1, Appendix 1).

For an infective agent to spread through a population, it must be transmitted from 'infectives' to 'susceptibles'. The diffusion through a population often has exponential dynamics and epidemic growth will continue as long as the infection rate exceeds the recovery rate. If the opposite is true, the infective agent will vanish. The latent variables are the 'infection rate' and the 'recovery rate'. The infection rate is influenced by the direct variables 'contact rate', 'infectivity' and the 'total population' at hand. The SIR model and its factors are useful to those who are concerned with epidemic growth in a business context (see Leskovec et al, 2007; Murphy and Long, 2009), because they provide a practical tool to understand how the volume of 'infected' individuals changes over time, once the population sizes, the contact rate and infectivity are established. Further, the SIR, model considers the mobility of infected carriers via the parameter of contact rate. Another advantage of an SIR perspective in a business context is that it includes the potency of the infective agent (infectivity), thus allowing to model competing ideas or products.

In many studies of epidemic growth, the classic SIR model from disease epidemiology is combined with an analysis of the network structure within the population (see Bobashev et al, 2007). Network structures compliment the SIR model by informing the topographic understanding of epidemic growth, i.e. where the epidemic will most likely begin and where to it will proliferate next. For example, individuals that have more social connections than others - called 'hubs' in network structure terminology – are associated with higher infectivity and contact rates (Iyengar et al, 2011). In addition, an understanding of the network structure contributes to the understanding of the propagation of the infective agent across compartments of the population that are separated by spatial and/or social distance, but connected via individuals that act as 'bridges' or 'connectors' (Bobashev et al, 2007; Hinz et al, 2012). A popular case that illustrates this idea is the story of Canadian flight attendant Gaetan Dugas, an early HIV infected

who played a pivotal role in the spread of the AIDS epidemic (McKay, 2014; http://www.ncbi.nlm.nih.gov/pmc/articles/PMC4046389/). Under a combined scientific lens of the SIR model and network structures, this individual was such a key element in the epidemic, because he was infective, had a high contact rate and acted as a bridge between otherwise separated compartments of the population.

Several works have applied the tenets of disease epidemiology to explain how large numbers of people subscribe to ideas or how products spread through a population. Among such accounts are sociological phenomena like the epidemic reversal of New York City's crime rate in the mid 1990's (Gladwell, 2002) and Paul Revere's ride through Massachusetts on April 18, 1775 [David Hackett Fischer, Paul Revere's Ride (New York: Oxford University Press, 1994)]. A specific strategy, which leverages the tenets of disease epidemiology and network structure to invoke and accelerate epidemic growth in a business context, is a practice called *seeding*. Specifically, seeding is the selective placement of offerings in place that promise high contagion. In an empirical application of epidemiology and network structures in a marketing context, Hinz et al (2012) find that seeding well-connected individuals within compartments and those that bridge otherwise unconnected compartments of the population is eight times more effective than other comparable strategies of product placement. Another benefit from an application of disease epidemiology and network structures is that businesses can more accurately forecast growth rates in specific territories.

One of the known weaknesses of a network structure lens is that network structures tend to shift quickly over time (Steglich et al, 2010), making a determination and targeting of hubs and bridges less reliable. Another limitation of applying a disease epidemiology perspective in a business context is that models for diseases do not consider individual expectations and decision-making: individuals usually do not choose whether they will be infected or not. This has important implications for epidemic growth in business contexts, because unlike most diseases, exposure and high infectivity is necessary, but often not sufficient to cause 'infection'.

Third, disease epidemiology is limited because it does not consider any driving forces other than the carrier and the infective agent (Leskovec et al, 2007). In other words, epidemiology does not take into account that growth processes can be influenced by exogenous factors, a random or deliberate event, such as a natural disaster, sudden market fluctuations, a public speech, a news report, or a breakthrough innovation in a related technology. Independence from exogenous events is not reflective of epidemic growth processes in a business context, thus limiting the application of disease epidemiology in such settings. Finally, disease epidemiology and network structure perspectives are limited, because they do not account for a critical juncture (tipping point) from whereon growth rates accelerate more rapidly and the process turns into a one-way journey. For example, disease epidemiology does not consider the potentially catalytic effect of exogenous events, like a public appearance or the arrival of a novel technology, which are known to affect growth rates in a business context.

A complex causal path dependency (CCPD) perspective of epidemic growth processes

A perspective that is fully compatible with the tenets of disease epidemiology and considers individual choice, a critical juncture, as well as exogenous events in the context of growth processes, is discussed in the context of political events by Bennet and Elman (2006), which the authors will refer to as complex causal path dependency (CCPD). They illustrate the applicability of a CCPD perspective to understand processes that start at the micro-level and lead

to an outcome at the macro-level with examples, such as the emergence of a new regime as studied by Luebbert (1991) or the evolution of the Monday Demonstrations in Leipzig/GDR between 1989 and 1991 as examined by Lohmann (1994).

Stages of an epidemic growth process under a CCPD perspective and case vignettes

Bennet and Elman (2006) identify the key stages along a complex causal path as causal possibility, contingency, closure and constraint. In the following, the author will explain the conceptual meaning behind causal possibility, contingency, closure and constraint and illustrate their applicability with case vignettes from two business cases of opportunities that resulted in epidemic growth: (1) the introduction of the next generation of portable music players in the late 1990's and (2) the advent of single-use Biopharmaceutical processing systems in the second half of the 2000's.

Causal possibility is the initial state when there is more than one feasible option, meaning more than one path to choose from. In a disease epidemiology perspective, causal possibility is the equivalent of latency, the state, when there is a susceptible population, but the epidemic is still dormant. Evidence of a latent epidemic is present in the case of portable music players[4]:

> Vignette -1a: In the 1990's in Western and Asian countries, there was a latent need in a large market for a new kind of portable music player. Most customers were hoping for better quality than walk-mans and smaller devices than portable CD players. For a while, possible contestants to capture this market were MP3 devices and Sony's Mini-Disk Player[5].

Similar evidence of a latent epidemic and competing offerings exists in the case of single-use Biopharmaceutical processing systems (SUBPS). In addition, this case provides evidence of the utility of a network structures perspective to identify and 'infect' key players in the market for the technology:

> Vignette-2a: In the first decade of the new millennium, a paradigm shift took place in Biopharmaceutical processing technology from re-usable to single-use equipment, in order to convert fixed into variable cost, increase flexibility and eliminate costs for cleaning and validation processes. Hence, there was a latent need for novel single-use processing systems. Most Biopharmaceutical manufacturers were hesitant to fully adopt single-use processing, while several key component technologies (e.g. valves, sensors, mixers) were still undergoing frequent changes. Companies who now dominate the SUBPS market then placed customized sample systems with strategic customers, who were known for exploratory process development and presenting their work at key conferences in the field.

Accordingly, the case of SUBPS shows evidence of deliberate attempts to 'infect' the population and initiate growth. The company who pioneered this practice - also known as seeding - at concerts, sports events and night clubs, as an alternative to more costly placement strategies is Red Bull, today's leading company in the market for energy drinks (Gorse et al, 2010; Johnson et al, 2016). Correspondingly, one interviewee notes the performance impact of focused 'infection' of the customer population stating that "viral product interest can limit the amount of spending needed on Sales and Marketing".

[4] http://www.cnet.com/news/study-mp3-player-market-to-explode/

[5] Faulkner, J. (2012): MiniDisk, the forgotten format.
https://www.theguardian.com/music/musicblog/2012/sep/24/sony-minidisc-20-years

In a CCPD perspective, causal possibility is followed by contingency and closure. Contingency represents the critical juncture, when a causal path is influenced by a random event or 'unaccounted factor' and one specific option becomes the most likely candidate to prevail. Closure in this context means that through the influence by a random event, other potential paths become less possible or even impossible, because individuals within and outside of the susceptible population expect one specific option to prevail. Similarly, Schelling (1978) describes cases where the way people made choices depended on how many 'other' people acted in a particular fashion and on the perceived intensity of 'other' people conducting themselves in that way. This concept, also referred to as critical mass, has been adopted by social scientists from nuclear chemistry. It describes the point where a process is able to sustain itself once a minimum amount of specific matter (the critical mass) is present. From this point onwards, the social process turns into a one-way-journey of epidemic growth. Evidence of a contingency event in form of the arrival of novel technology and closure is present in the case of portable music players:

> Vignette-1b: During the time of this latent need, the confluence of rising internet adoption and MP3 technology becoming the standard for music on the internet[6] provided the contingency event that favored MP3 players and triggered enormous growth rates. Closure happened when the population expected MP3 technology to prevail and started building their music libraries in this format.

Likewise, contingency events and closure played an important role in the case of single-use processing systems:

> Vigntette-2b: During the early years of single-use processing systems, companies that now dominate this market began to acquire or form strong strategic links with suppliers of key component technologies such as control valves and sensors. During that period several breakthroughs were made on valve and sensor technology, which triggered an exponential hike in demand for single-use processing systems. Closure occurred when the population of Biopharmaceutical manufacturers expected systems with certain component technology to prevail.

Correspondingly, the moment that initiated the epidemic growth in the case of Breathometer was when the owner, Charles Yim, appeared on Shark Tank in 2014 (Pai, 2014). Contingency in the case of energy drinks, such as Red Bull, occurred and sales exploded "when barkeepers and nightclub owners realized, they could use [them] as a mixer" (Steen and Knoop, 2016).

One of the interviewees stresses the importance and performance impact of understanding and actively managing the stage at and just after the critical juncture: "Without an understanding of the dynamics of the tipping point and the enhanced growth that follows, a business can be unprepared to support this customer interest. Manufacturing and raw material buying would seem to be the most at risk activities as they often represent the longest cycle times in the fulfillment process. Not adequately supporting this initial customer interest puts you on an often dramatically different growth curve and closes the opportunity of "exponential" growth of your product." The interviewee continues by emphasizing the impact of timing of investments during this stage: "Trying to catch up to rapid business growth limits the options the business has

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6 http://www.euras.org/uploads/2012presentations/den%20Uijl,%20de%20Vries,%20Bayramoglu_Rise%20of%20MP3%20as%20the%20market%20standard.pdf

for how to do so and typically requires heavy, short-term investment in resources and expediting fees."

In the final stage in a CCPD perspective, constraints occur after one specific option becomes more likely after closure, and reinforce the direction of the path. Specifically, individuals that are external to the susceptible population will treat the selected option as a standard and tailor their actions to fit this option and not others. For individuals in the susceptible population, it becomes increasingly costly to select another alternative or to return to the original state. Constraints emerged and reinforced the direction of the path in the portable music player epidemic:

> Vignette-1c: Shortly after MP3's emerged, practically all music was traded in this format and therefore constrained listeners to players that supported it. In addition, interfaces with auxiliary devices (computers etc.) were tailored to fit MP3 players further constraining the use of other portable equipment.

Correspondingly, constraints emerged in the case of single-use processing systems:

> Vignette-2c: Following the improvements in component technology, Biopharmaceutical manufacturers began to standardize the specifications for their manufacturing equipment around the key components. Companies that now dominate this market began to work on development of proprietary interfaces between their parts in the system and the key components further constraining the use of other systems.

The case of Breathometer parallels this strategy of creating and emphasizing constraints through complimentary products and services. Specifically, Breathometer now collaborates with Uber, a transportation service business, by calling customers who use Breathometer and are over the legal blood alcohol level a ride (Buhr, 2015).

In summary, the review of the process characteristics together with the case evidence suggests that epidemic growth in business contexts occurs in accordance with the stages of a CCPD perspective. Specifically, the process begins with the stages of latency and infection, corresponding to the state of casual possibility, progresses to a critical juncture, equivalent to the states of contingency and closure and continues with the emergence of constraints in form of complementarity and standardization. Finally, the case evidence also implies that effective resource allocation during epidemic growth periods occurs with focus and in accordance with the stages of the epidemic growth process. Overall, the results indicate that businesses can benefit from a careful analysis, using a combined CCPD and epidemiology perspective, because, as one interviewee notes, "an understanding of epidemic dynamics should allow better investment, planning and communication amongst the key roles responsible for fulfillment of orders."

DISCUSSION: STRATEGIC RESOURCE ALLOCATION DURING EPIDEMIC GROWTH STAGES

In this section, the author will discuss how resource constrained businesses can employ the findings about process characteristics of epidemics and the case evidence to strategically allocate their resources during epidemic growth periods, as shown in Table 1 (Appendix 2). As noted in the introduction, most entrepreneurial ventures are constrained in terms of resources and can therefore benefit from strategic focus in the resource-allocation process (Murry and Long, 2009). Moreover, the findings from this study suggest that effective resource allocation occurs in accordance with the stages of the epidemic growth process. To that end, Table 1 presents the

proposed strategic focus in the allocation of Marketing and Operations resources to each stage of the epidemic growth process.

For example, the findings from the SUBPS and the MP3 player cases suggest that during the stage when the epidemic is latent, strategic focus should be on investigating the population size and structure to derive estimates for the expected progression of sales volumes and locations, as well as for the determination of optimum seeding points. The evidence from the SUBPS case, as well as Red Bull's early product placement approach, afford insight about how seeding with customized product versions at strategic locations (bridges and hubs) can be an effective and efficient way to infect the population. Perhaps the most crucial stage to be recognized in the epidemic growth process is the critical juncture, when growth rates begin to accelerate rapidly and the epidemic becomes a one-way-journey. Murry and Long's (2009) work, for example, suggests that when growth rates are accelerating, i.e. right after the critical juncture, the business can benefit from a proactive and responsive mobilization of resources. The case evidence gives more specific insight about strategic focus during this stage of the process. In particular, in Marketing, strategic focus should be on monitoring for exogenous events, such as public appearances of similar products and actively pursue opportunities for their own product. In parallel, strategic focus in Operations should be on monitoring for the arrival of new component technologies. Further, the interviews and the case of Breathometer suggest that mobilizing production (e.g. contract manufacturers) and distribution channels too late will result in lost sales and reputation. Mobilizing too early, on the other hand, will result in unnecessary capital and inventory cost. Accordingly, the better the critical juncture is understood, the more accurately will the business be able to mobilize its resources. Finally, the cases and process characteristics tell that constraints will further fuel growth rates and allow to better predict and capture demand. Accordingly, strategic focus during this stage in marketing should be on emphasizing constraints, such as standardization of product interfaces, and the value of complementarity with other products. In Operations, strategic focus should be on strengthening the relationships with makers of complimentary components and products.

IMPLICATIONS FOR PRACTICE AND FUTURE RESEARCH

This study has shown that companies, specifically resource-constrained businesses, can benefit from careful analysis of and focused resource allocation during epidemic growth periods. For example, the interviews and cases provide evidence that actively monitoring and managing the stages at and just after the critical juncture can prevent unnecessary expenses for expediting fees and improve delivery reliability and, by extension, reputation. The results of this study have a number of pragmatic and scientific implications. For example, managers in small, resource-constrained businesses could use the findings summarized in Table 1 (Appendix 1) to create strategic maps for the growth process of their enterprise. Specifically, this study suggests that a strategic map, which breaks down an epidemic growth process in distinct stages derived from combining a CCPD perspective with the tenets of disease epidemiology can guide the deliberate, focused resource allocation process for entrepreneurial businesses. Finally, future research could extend this work and employ a CCPD perspective together with disease epidemiology to conduct field work on the performance implications of strategic orientation of businesses during epidemic growth periods.

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APPENDIX

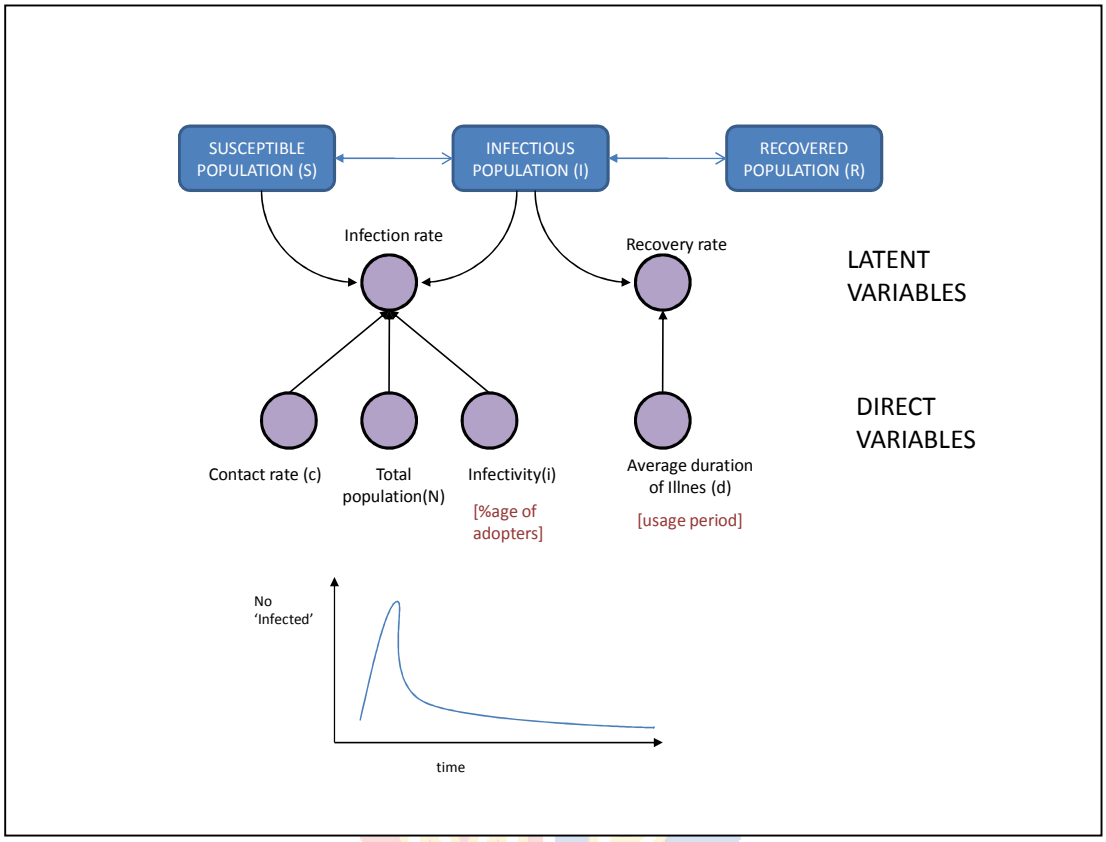

Figure 1: Graphical representation of the SIR model

Appendix 2

Stage	Case Example	Marketing strategic focus	Management (Operations) strategic focus
Latency	• SUBPS • MP3 players	• Investigate population size and structure (SIR model) • Identify hub's and bridges (network structure)	
Infection	• SUBPS • Energy drinks (Red Bull)	• Seed hubs and bridges	• Provide customized seeding batches of product/service and revise design
Critical Juncture (Tipping Point) & Closure	• Breathometer • SUBPS • MP3 players • Energy drinks	• Monitor for and immediately respond to exogenous opportunities • Pro-actively mobilize distribution channels	• Monitor for and immediately respond to arrival of new component technology • Pro-actively mobilize production (e.g. contract manufacturers)
Constraints	• Breathometer • SUBPS • MP3 players	• Emphasize constraints and complimentary products	• Strengthen relationships with makers of complimentary components and products

Table 1: Strategic focus in the resource-allocation during epidemic growth periods