Forecasting Competition between Disruptive and Sustaining Technologies in Business Ecosystems

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***Abstract*--Contemporary business environment is increasingly built around business ecosystems that combine multiple stakeholders utilizing multiple technologies. Measures assessing technological changes in these systemic contexts are vital as organizations are required to manage their innovation processes in increasingly networked and complex environments. This paper utilizes the market share of technology utilization as a measure of technology-based competition and explores possibilities to forecast technological competition in business ecosystems with analogies. The study analyzes systemic changes in the personal computer game ecosystem, explicitly focusing on technological competition in sub-technologies that are central to the delivery of gaming value to the end-user. The paper subsequently discusses organizational considerations and theoretical implications of the proposed measures and their forecasting performance.**

I. INTRODUCTION

Disruptive technological change interrupts the traditional performance evolution of a technology system in its aspiration to deliver value to end-users [8]. As this disturbance is created new performance parameters are introduced to the marketplace and at the same time new business processes are introduced or the old ones are significantly changed. Therefore, disruptive change induces multiple influences to the competitive dynamics and in many cases signifies a change also in market power and share balance between competitors. But disturbance also has wide-ranging effects throughout the collaborating and complementing networks of organizations that are part of the value delivery to the end-user, the whole business ecosystem is changed at least to some extent.

Just as biological ecosystems consist of a variety of interdependent species, business ecosystems analogously depict interdependent networks of organizations, which collectively produce a holistic, integrated technological system that creates value for customers [5, 6, 7, 26, 36, 39]. In this network, each member contributes to the ecosystem's overall wellbeing, and is dependent on other members for its survival. These organizations "co-evolve capabilities around a new innovation" by working cooperatively as well as competitively in the creation of products and services [29]. Reciprocally, the survival and success of each member is influenced by the ecosystem as a holistic entity that is in continuous evolution [20].

There have been a number of calls for furthering our understanding of ecosystem-based thinking in recent years. Reference [40] for example calls for additional analyses on "how structures emerge, proliferate, and morph into other structures" in business ecosystems. Similarly recent workshops have called for advancing our understanding of the concurrent networked business environment, for example [24] calling for deepening the understanding of ecosystems processes and functions, [2] calling for understanding of co-evolutionary processes across systemic levels in ecosystems, and [3] calling for further investigations of technological change and value creation in business ecosystems. These and similar calls for attention have readily witnessed that concurrent economic activity centers around co-dependent and co-evolving entities and processes that are highly dynamic and therefore require holistic system-level analyses that address the complexities involved.

The present paper investigates disruptive technological change and utilization of disruptive technology in systemic contexts. The aim is to uncover how the disruptive technology is utilized alongside with the incumbent technology and what is the dynamics of this change from sustaining technology to the disruptive. Specifically, the paper reports results of a study in computer game ecosystem and limits its temporal scope to only consider recent advances to multi-core from single core central processing unit (CPU) architecture.

II. THEORETICAL BACKGROUND

The business ecosystem framework forms a relatively new strand of research in the management literature, with Moore's seminal article [29]. After this opening a number of scholars have made contributions to business ecosystem research albeit with different constructs to describe the ecosystem, including "industrial ecosystems" [13, 34], "product ecosystems" [14], "service ecosystems" [26], and "technology-based ecosystem [33]. The business ecosystem may comprise a variety of actors, including suppliers, complementors, system integrators, distributors, advertisers, finance providers, universities and research institutions, regulatory authorities and standard-setting bodies, the judiciary, as well as customers [4, 22, 25, 28, 31, 37, 38]. Through the ecosystems approach, firms can analyze their own businesses through a wider lens [1] by considering not only the suppliers and direct adopters of their innovation but also complementors with which they cooperate laterally in delivering a product or service.

As a result, the ecosystem does not necessarily align with a particular industry but rather cross over different industries in delivering value to the end-user. Unlike alternative scientific approaches which see the network as a static entity, the business ecosystem model have come to emphasize the change dynamics that exists in the network, and in turn, the implications that such dynamics can have on member organizations [9, 20, 29].

Business ecosystem as a construct has permeated to public and scientific discourse in the last twenty years. Especially during the last five years it has gained momentum in popular accounts in describing business dynamics and competition between groups or networks of firms. For example competition between mobile phone manufacturers has increasingly been referred to as competition between ecosystems like Apple, Android, and Windows ecosystems [7, 35]. Other similar notions have been e.g. the internet ecosystem [23, 30, 38], the microprocessor ecosystem [16], the biopharmaceutical ecosystem [15], Amazon's web service ecosystem [21], Cisco's business ecosystem [25], and Deutsche telecom's open innovation ecosystem [32].

The build-up of business ecosystems depends in many cases heavily on platforms which form the core of the ecosystems around which the actors are gathering and acting. Reference [9] identifies three main types of organization that make up ecosystems – platform leaders, wannabes, and complementors. Most importantly, the 'platform leader', akin to Moore's ecosystem leader, plays the vital role of regulating the overall function of the ecosystem and as a consequence its actions influence the success of all other members. The key to the success of these firms is their ability to provide platforms (e.g. tools, technologies, manufacturing processes, and services), which other members of the ecosystem can utilize in developing their own offerings [9, 17].

Reference [4] points out that without the sufficient level of technological development from component and complementary firms in its ecosystem, the innovation efforts of the focal firm may be rendered impotent. This highlights the need for component and complement producing firms to make appropriate investments that will boost technological performance in their own products, and also for platform leaders to coordinate the ecosystem to circumvent the reluctance of ecosystem members to invest in innovation [4] and utilize new technologies.

In business ecosystems, technological evolution is curbed by the emergence of bottlenecks when a particular complement or component producer lacks in utilization or development of technological potential. These bottlenecks, or reverse salients [11, 12, 19], have been shown to hinder the attainment of a higher level of technological performance by limiting end-users' value attained from the usage of ecosystems offering [4]. Especially from the vantage point of utilization of technological potential is the bottleneck created by the complementors' reluctance to utilize technological potential provided by the focal firm. Fig. 1 represents the focal point of the present paper in that complementor that utilizes technology provided by focal firm in its products becomes bottleneck as its ability and willingness to utilize provided technology determines, in part, the value gained by the end-user from the ecosystems total offering.

Reference [17] has pointed out the need for considering the criticality of distinction of activities centering around products inside ecosystem and platform decisions inside ecosystem. As product decisions are in control of one company but platform decisions are not independent of other products as they derive their value from inter-dependent products. Especially these considerations become crucial as the focal firm is developing disruptive technologies that derive their value from the complementors' offering in end-users usage situations.

III. RESEARCH METHOD AND DATA

The present paper contributes to existing literature in that it reports results of a study investigating utilization of disruptive technology of a focal firm by complementors, namely the empirical study delves into utilization of a single-core CPU architecture as the multi-core CPU architecture is introduced to the market place. Multi-core may be considered as disruptive as it dramatically changes the coding procedures, brings new parameter to customers' attention and changes the market dynamics. Similar investigations in different gaming systems have been conducted earlier eg. by [10]. At the same time as the multi-core represents new system as such it still closely resembles the single-core and therefore we explore whether we could find meaningful forecasts using analog of single core evolution in forecasting multi-core evolution.

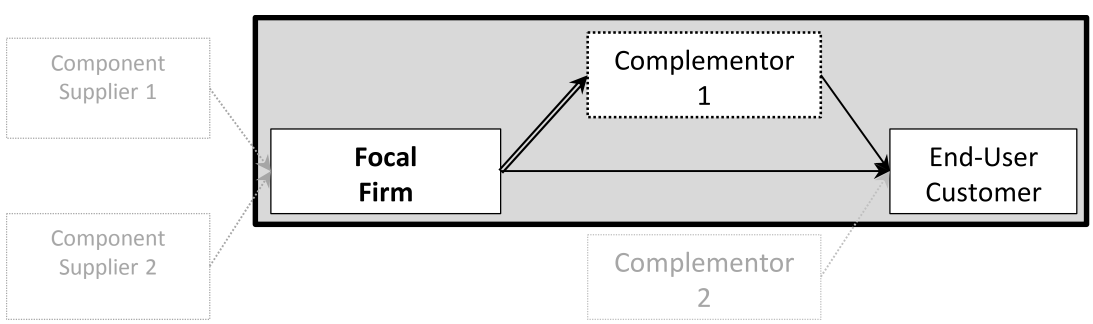

Figure 1. A schema of a part of the business ecosystem and location of bottleneck in complementor. Double-line represents utilization of focal firm's technology by complementor while single-line represents delivery of offering to end-user.

The paper uses similar framework than [11, 12] in that PC games' minimum requirement specifications are used as a proxy for technology utilization in business ecosystem. In contrast to earlier research [11, 27] this research tracks all the PC game launches between 1.1.2004-31.12.2013 without screening them to be published major outlets or otherwise. The data has been acquired form Amazon.com and the empirical material includes PC games' minimum requirement specifications for CPU i.e. what CPU is required for the PC game to function. The empirical material includes specification of 2779 games in total. The timeline considers specifically radical change in technological advancement namely introduction of multi-core processors in 2005 to personal computer markets by a focal company, Intel.

IV. RESULTS

Firstly, the number of PC game titles based on different CPU architectures was analyzed and these results are depicted in Fig. 2.

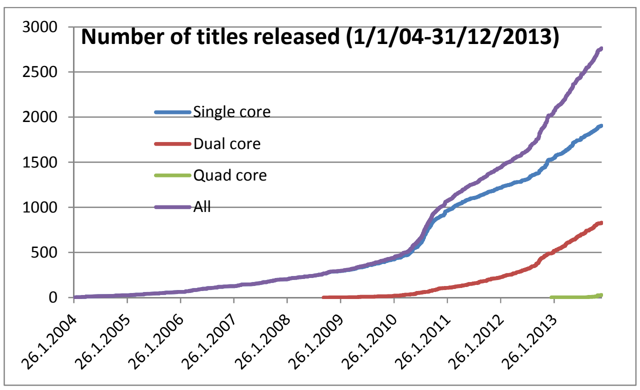

Figure 2. The number of PC game titles released during the research period.

As is evident from the Fig. 2 the dual-core architecture has been slowly adopted as a minimum requirement for PC games starting from 2008. However, the share of dual-core processors as minimum requirement has steadily increased and during the 2013 has reached a similar level to that of the incumbent, sustaining technology of single-core architecture. Also evident from the Fig. 2 is that quad-core architecture has not yet been adopted largely as a minimum requirement and its utilization in PC game part of the ecosystem is still in its infancy.

In order to investigate further the dynamics of utilization of new technology we calculated the market share of each CPU architecture from the total number of PC game titles released since 1/1/2004. These results are depicted in Fig. 3. The single core CPU architecture holds most of the markets and is widely utilized by complementors that design PC games. However, since 2010 the share of PC games that stipulate dual-core as a minimum requirement significantly increases and reaches about one third of all titles released after 1/1/2004.

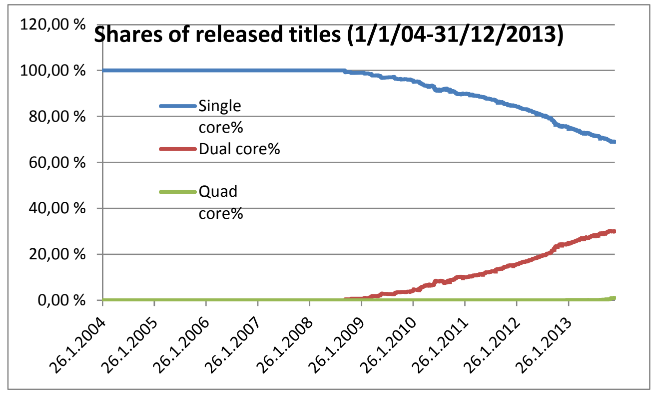

Figure 3. Share of technology utilization in titles released according to the design of CPU (single vs multi-core).

Based on the results in Fig. 3, the investigation continues on analyzing the yearly dynamics of market shares between different CPU architectures. The PC games are evaluated by the market in contrast to the existing market conditions and for example games are evaluated in par with other games in the market as a new title is released. Therefore, all the PC games are competing with one another in a temporally constrained timeframe. Similarly, to the PC game industry yearly seasonal sales of late December are crucial and after the Season ends a new, starting year marks a significantly different market condition and context. Therefore, the analysis continues comparing the market share of CPU architectures year by year and these results are depicted in Fig. 4.

No dual-core processors are presented as minimum requirements for PC games in our dataset before 2008, therefore the year by year analysis starts from 2008. The share of dual-core steadily increases after 2009 and is on par with single core architecture in 2013. Results in Fig. 4 clearly point to the evolutionary path of dual-core architecture penetrating the utilization barriers year by year as the market share rises from about 5% in 2009 to about 20% in 2010 and continues to about 30% in 2011. Surprisingly, in 2012 and 2013 the technology utilization is divided evenly among single and dual-core processors. The quad-core architecture starts to penetrate utilization in 2013 with a peak early on in 2013 but this is mainly due to the small amount of total titles release thus far during the year.

Using dual-core as an analog to forecast quad-core utilization we anticipate that in 2014 it will reach few percentage of market share as the single core architecture still loses market share for multi-core and will go below dual-core. The quad-core will have a market share of 10% in 2015, about 25% in 2016, about 40% in 2017 and about 50% in 2018. At the same time we see the decline of incumbent single-core architecture steadily decreasing from 50% in 2013 to diminish from markets 2017.

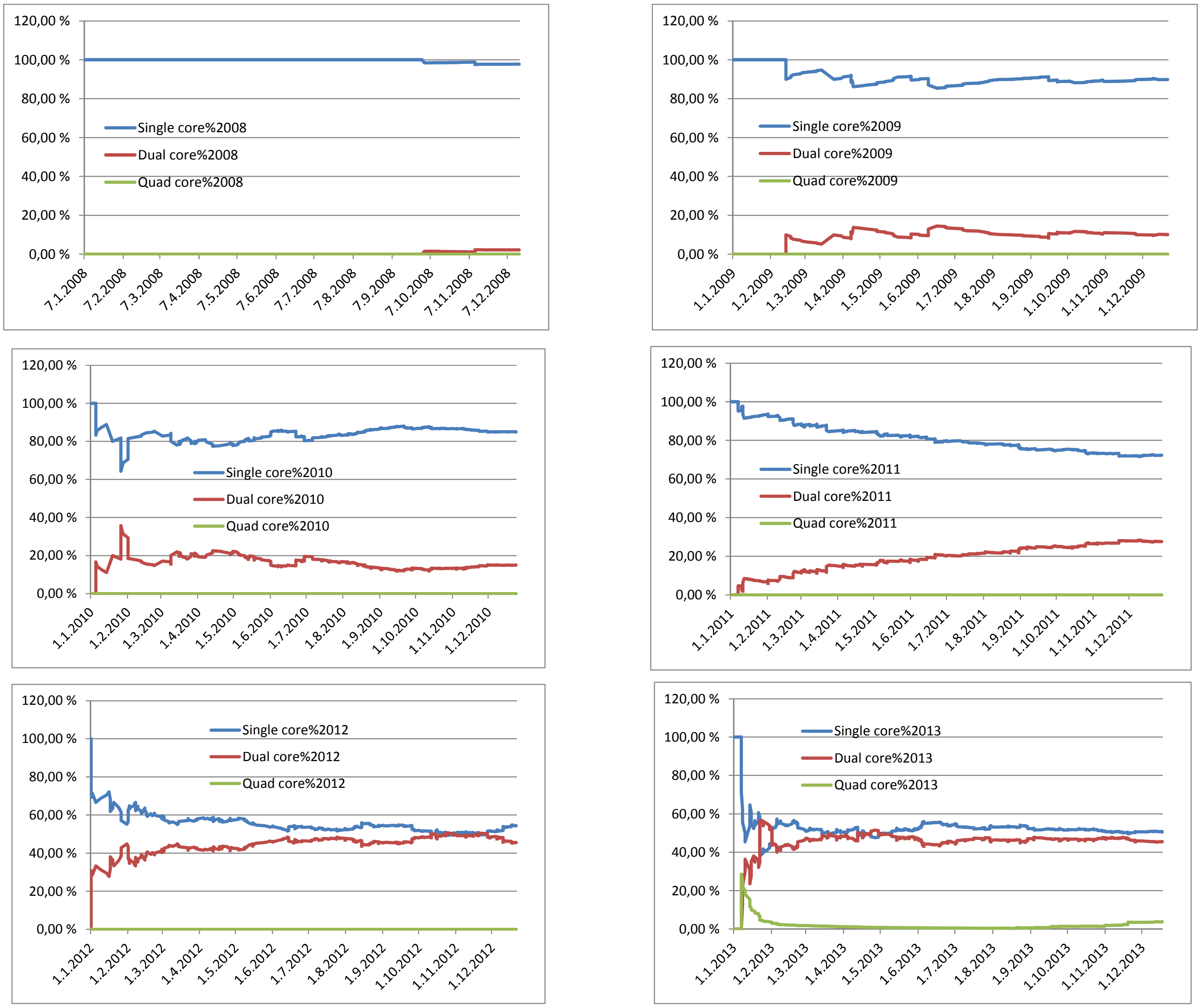

Figure 4. Yearly shares of technology utilization.

V. DISCUSSION AND CONCLUSION

Firstly and most significantly, even in highly dynamic industries like our example of PC games and microprocessors, it takes many years for the disruptive technology to penetrate the mainstream. The market shares of new technologies gradually penetrate the lower ends of the customer requirements. This is in stark contrast to popular notions of speed being the competitive edge in utilizing the latest technologies in highly dynamic industries.

Secondly, even as the utilization of disruptive technology progresses the incumbent technology seems to be able to deliver sufficient amount of value to complementors so that their products can compete with one another without the large scale adoption of the new disruptive technology. However, increasing amount of PC game designers see the competitive value in utilizing new multi-core architecture but the share of single and multi-core architecture remains on par. This signifies a competitive balance in that old technology is able to deliver enough value and at the same time new technology provides additional value but it does not permeate the whole industry. Limitations naturally include considerations like the installed base of single versus multi-core which necessarily influences the PC game designers. As single core is much more prolific in the market place and its installed base (presumably) is larger in order to target as large market as possible, PC game designers are sticking to the older technology as a minimum requirement. Also the difficulties in designing software for the new multi-core architecture are not considered here and it could influence the utilization of multi-core as a minimum requirement.

Therefore, the results show that even with disruptive technological change the timeframe that companies have to adjust their offering and competitive startegy to new situation is quite long, even in hyper-competitive environments like PC game industry.

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