Accepted Manuscript

Co-evolution between streaming and live music leads a way to the sustainable growth of music industry – Lessons from the US experiences

Kashif Naveed, Chihiro Watanabe, Pekka Neittaanmäki

PII: S0160-791X(17)30011-8

DOI: 10.1016/j.techsoc.2017.03.005

Reference: TIS 979

To appear in: *Technology in Society*

Received Date: 16 January 2017

Revised Date: 31 March 2017

Accepted Date: 31 March 2017

Please cite this article as: Naveed K, Watanabe C, Neittaanmäki P, Co-evolution between streaming and live music leads a way to the sustainable growth of music industry – Lessons from the US experiences, *Technology in Society* (2017), doi: 10.1016/j.techsoc.2017.03.005.

Co-evolution between Streaming and Live Music Leads a Way to the Sustainable Growth of Music Industry – Lessons from the US Experiences

Kashif Naveed [a], Chihiro Watanabe [a,b], Pekka Neittaanmäki [a]

[a] Faculty of Information Technology, University of Jyväskylä, Finland

[b] International Institute for Applied Systems Analysis (IIASA), Austria

Abstract

While digitization of music, particularly streaming services, has gained increasing popularity, it has also led to a steady decline in the revenues of recorded music industry. This is causing strong concern regarding a potential collapse of the music industry comparable to other print media industries such as newspaper and book publishing.

However, recent changes in the music industry initiated by a resurgence of the live music industry are giving rise to some expectations for the survival and growth of the music industry. The parallel paths of increasing popularity of streaming services and a resurgence of live music suggest that these two dynamics are working together in a co-evolutionary way toward the sustainability of the music industry.

This paper attempts to elucidate the co-evolutionary dynamism between the increasing popularity of streaming music and the resurgence of live music.

An empirical analysis of monthly trends over the period of the last three decades in the US music industry by its sectors revealed that (i) the co-evolution between streaming and live music industries has functioned well over the last few years, (ii) the live music industry has incorporated a self-propagating function by assimilating innovations previously initiated by digital music, (iii) given the above co-evolution, the recent resurging trend in the music industry can be sustained, (iv) the advancement of digital innovations such as artificial intelligence, machine learning, fintech, virtual reality, big data, and social media by enabling such coevolution have transformed the live music industry into a "live-concert-streaming music industry" (*LCSMI*) that further enabling the participative creativity of its stakeholders. For these collaborative and cultural industries to function in harmony, trust between its participating stakeholders is very crucial.

This analysis suggests the significance of a trust-based ICT-driven disruptive business model (IDBM) with a consolidated challenge for social demand (CCSD) for the development of cultural industries.

Keywords: Music industry, live music, live-concert-streaming music industry, co-evolution, trust-based IDBM with CCSD, cultural industries

Corresponding author
Chihiro Watanabe (watanabe.c.pqr@gmail.com)

1. Introduction

Music is an integral part of our societies all over the world. It is an art that strives to feed our soul and paint a canopy of emotions through songs (Stafford, 2010), and music has always been playing an inspiring role in our cultural activities. Music as an industry[1] truly incorporates a wide-range of businesses. Digital music, which emerged in 2004, is considered to be premier example of digital innovation, having provided the music industry with new disruptive business models and new digital music products and services for consumers.

The United States plays a leading role in the global music industry and has played a pivotal role in the development and consumption of digital music.

Fig. 1 shows the magnitude of the recorded music industry[2] in leading countries by their revenues in 2014 which represents the major input share in music market. This figure clearly demonstrates the leading role of the US in the global music industry, particularly in the digital music.

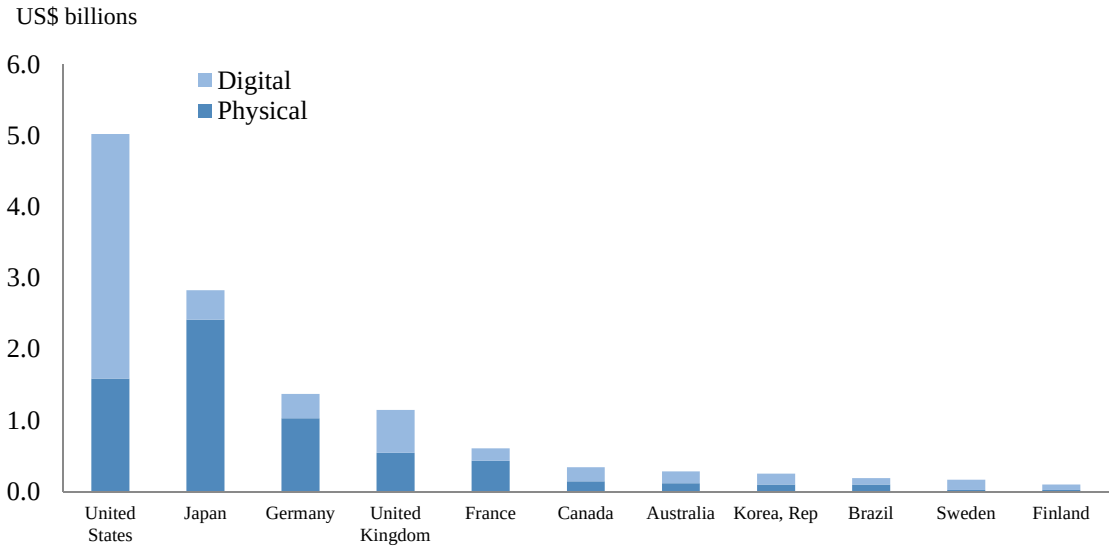


Fig. 1. International Comparison of Music Industry by Revenues *(2014)*.

Source: Musically (Music Ally Data map, Global Music Industry Data on Sales.).

The music industry has undergone huge changes recently. Although the digital music, particularly streaming services has gained increasing popularity, there is a steady decline in revenues of the recorded music industry. This has caused a potential impending collapse of the music industry similar to print media industries such as newspaper and book publishing.

[1] Music industry is defined as an industry selling compositions, recordings and music performances. Individuals and organizations operating within the industry include: (i) musicians (artists) who compose and perform music, (ii) companies and professionals who create and sell recorded music, (iii) organizations involved with and giving music performances, (iv) professionals who assist musicians with their music careers, (v) those who broadcast music, (vi) journalists, (vii) educators, and (viii) musical instrument manufactures.

[2] Recorded music only, live music not included.

Fig. 2 overviews the development trajectory of the US music industry over the period of 1950 - 2015 by revenues of its different sectors: live music and recorded music. The recorded music consists of both physical and digital music (See Appendix 1 for the significance and implications of this data).

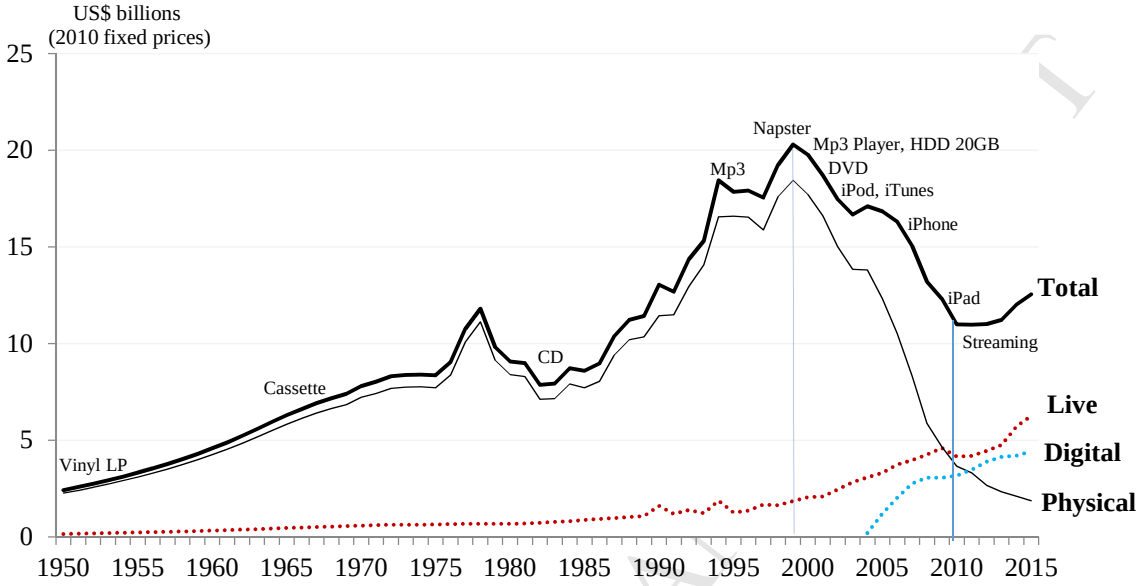


Fig. 2. Development Trajectory of the US Music Industry by Revenues *(1950-2015)***.**
Sources: RIAA (Recording Industry Association of America), Pollstar (Trade publication for the concert tour industry).

In Fig. 2, we note that the US music industry has continued to develop except during the period of economic recession in the early 1980s. However, this increase finally reached its peak in 1999 and after the expansion of the Internet, it declined. The direct relationship between the widespread access to the Internet and decrease in the record music sales can be observed, apparently because the Internet has enabled everyone to allocate, listen, download and stream music for free. Digital music emerged during 2004, but it was also seemingly unable to become the savior of the declining music industry. Another issue is the lack of trust relationship between artists and music companies. Many artists seriously thought of being too reliant to and unfairly compensated by the record companies and digital music service providers and they shifted their focus towards concert tours as their primary source of income.

In 2010, the continued decline in music industry revenues suddenly changed and turned upward largely due to the renaissance of live music industry[3]. The music revenues were increased by 15% between 2010 and 2013, and reached 30% until 2015. In recent years, live shows have become increasingly popular and valuable because live music is something fans cannot fully experience merely by listening to recorded or online music. Due to this shifting trend the balance of power in the music industry has also firmly shifted away from record labels towards the value chain of live music. Nevertheless, the value chain of live music is incredibly complex with its multiple stakeholders (e.g., ticketing, secondary ticketing, venues, booking agents, promoters, taxes and other

[3] The performances take place at clubs, music theaters, arenas, amphitheaters and local/regional music festivals.

expenses, etc.), with each taking their revenue share and such layers of complexity necessitate the strong trust relationship among the participants of this value chain. El Gamal (2012), demonstrated that rise of the spread of the Internet, suggests that it may be one possible explanation for such a shift seen by some as contrary to the recording industry's interests. The internet has enabled even less-known artists to easily produce, market and distribute their music online building a solid fan base, whom they may attract and capitalize through their live concerts. The social media phenomenon and growth of online music communities have also contributed to the growth of the fan base, allowing the rising artists to easily connect through new digital marketing techniques for their already established acts. The author also pointed out another notable shift in the live music industry occurred with the widespread popularity of music festivals. Although it seems quite unlikely that live concerts could serve as the sole revenue stream for a viable music industry model, its rapid growth offers new valuable opportunities for the music industry (El Gamal, 2012).

Depicting this noteworthy resurgence of live music, **Fig. 3** reviews the details of the actors supporting this resurgence game in the digital music era. Fig. 3 also suggests that streaming music has been gaining popularity and demonstrating the sustainable growth by substituting the music downloading services. There has been observed a clear shift in the number of consumers who select streaming as a primary source of their music consumption contrary to all other formats of recorded music. With every other format of the recorded music industry declining, it seems that the streaming music could be the potential driving force behind the growth of the live music industry (Fly, 2016).

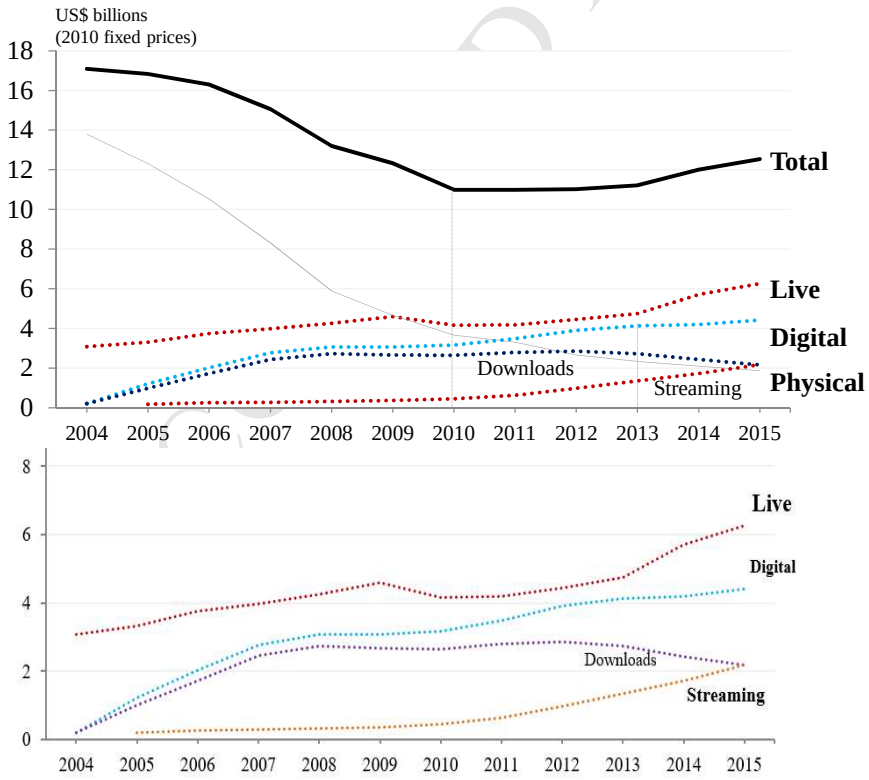


Fig. 3. Development Trajectory of the US Music Industry by Revenues *(2004-2015)***.**
Sources: RIAA and Pollstar.

This pattern suggested that there could be parallel paths of sustainable growth in which the resurgence of live music may have a co-evolutional dynamism. The result would be a virtuous cycle between sustainable growth of streaming services and the resurgence of live music.

In addition, the resurgence of live music can largely be attributed to its dependency on similar advanced digital innovations (**Table 1**). Another important factor is that music streaming services are gaining popularity despite the general declining trend in the music industry. This resurgence can also be attributed to the assimilation of the preceding digital innovations, particularly on those initiated by streaming services and on those introduced by downloading services.

Table 1 Advanced Digital Innovation Supporting the Resurgence of Live Music

Artificial intelligence	Creates algorithms enabling the creation of customized songs for users and helps artists to focus more on being creative.
Machine learning	Enables consumers to draw on past information, leading to increased trust among stakeholders.
Fintech	The rise of the blockchain and bitcoin creating new methods of sharing, creating and selling music.
Virtual reality	Artists can create interactive virtual worlds, allowing fans from all over the world to share experiences and open up new worlds and also enabling disabled (financially and physically) people to enjoy live music.
Big data analysis	Provides sources for real-time personalization by compiling wide-ranging personal information (e.g., purchasing history, listening habits, physical and mental conditions).
Social media	Exploring new distribution channels (e.g., Facebook, Twitter, You Tube)

Furthermore, the impacts of the changing consumer preferences should not be overlooked (Fly, 2016). The general trend in the shift of people's preferences from economic functionality to supra-functionality beyond economic value (encompassing social, cultural, aspirational, tribal and emotional values, which are more personalized and people are more active) (Watanabe et al., 2015*a*). This may further accelerate our higher dependency on live music while maintaining streaming as a (temporal) complement of this radical shift, because of its comparative advantages of discoverability, accessibility and portability. In addition, in many industries a transformational shift is taking place from value creation to value co-creation, which is fundamentally changing the relationship between consumers and producers (Choi et al., 2013).

Thus, streaming, accompanied by live music sales, may actually be the driving force behind the survival and new growth of the music industry (Fly, 2016). This led us to our hypothesis that the notable resurgence in live music can largely be attributed to its assimilation of digital innovations incorporated in digital music and this assimilation has been enabled by the co-evolution between streaming and live music industries.

This paper attempts to demonstrate this hypothesis.

To date, a number of studies have analyzed the music industry and provided a warning of its possible collapse. Gronow (1983) suspected that recorded music might face this crucial situation point due to the general economic recession, the influence of private copying, and competition from other media. In addition, this situation was also due to the industry reaching its saturation level.

The boom of the music market due to the CD emerged in the beginning of 1980s, the subsequent sharp rise in sales and revenue figures masked the fundamental problems of the music industry. After the availability of music tracks online over the internet, the CD became obsolete and revenues of the music industry sharply declined.

Tschmuck (2010) pointed out that the organizational inertia of the established music industry is the fundamental source of its decline. In addition, the overall market for recorded music has become a market for long-play formats, which reflects a business strategy that has been pursued mainly by the major record companies since the late 1960s. Stafford (2010) showed that increase in music stealing might led to a vicious cycle where the decrease in revenues of the record labels and the decrease in investment savings for the development of artists resulted in declining popularity of recorded music.

Confronting this collapse, quite a few reports and articles suggested an expectation of a resurgence of music industry initiated by the live music industry.

Turner (2015) pointed out the following seven trends that were impacting the live music business:

(i) Fans expect a mix of options and more personalized experiences,

(ii) Hybrid music events bring in bigger audiences and more money,

(iii) Online ticketing unlocks powerful data and insights like never before,

(iv) Mobile technology improves the overall attendee experience,

(v) RFID (Radio frequency identification) technology and smart cards add value, once inside the event,

(vi) Social media provides hard cash benefits to event organizers, and

(vii) Live streaming events keep fans connected and engaged digitally.

Explaining this powerful shift, Kirshbaum (2016) pointed out that the music industry had been shifting in the following ways:

(i) Increasing dependency on brands for music strategy development,

(ii) Continued rise of emerging artists,

(iii) Continued streaming wars,

(iv) Highly brand- and technology-centric festival culture,

(v) Music as a bridge to consumers for fashion brands, and

(vi) Wearable technology blending with streaming music for new user experiences.

These trends suggest that live music will transform music into a new music industry. Fly (2016) suggested that “It is likely that a combined industry consisting of both streaming

and live music will continue to grow in the near future." He also anticipated that in order to take advantage of this trend, the artists would likely find the most success in promoting their music through streaming services and by conducting live tours.

However, all these analyses remain phenomenological observations or conceptual analyses, and to our knowledge none of the studies have analyzed the structural dynamism that may enable resurgence of the music industry using econometric modelling. This co-evolution of the increasing popularity of streaming music and the subsequent assimilation of the preceding innovations in digital music, are econometric sources of the resurgence of live music.

In light of the econometric system or "dynamism", this paper undertook an empirical analysis focused on the US, because it leads the global music industry. The dynamism analysis was conducted by using the monthly development trajectories of different sectors of the US music industry over a period of the last three decades, with a special attention given to the era of digital music.

It was revealed that (i) the co-evolution between streaming and live music has functioned well over the last few years, (ii) the live music industry has incorporated a self-propagating function by effectively assimilating the innovations previously initiated by the digital music, (iii) given the above co-evolution, the recent resurging trend in the music industry can be sustained, (iv) the advancement of digital innovations such as artificial intelligence, machine learning, fintech, virtual reality, big data, and social media has enabled the above co-evolution and led the transformation of live music into a "live-concert-streaming music industry" (*LCSMI*). The *LCSMI* enables the participative creativity of its stakeholders. *LCSMI* corresponds to the historical demand of consumers and also of society.

As the consumer preferences has been shifting from *viewership* → *physical ownership* → *digital ownership* → *access* → *viewership and access*, so the consumers are not the passive listeners anymore, they want wide range of choices and are willing to actively participate, integrate and co-create value. The emergence of collaborative platform such as *LCSMI* reflects the historical demand of consumers but for the successful implementation of such collaborative business environment the importance of trust among its stakeholders is crucial.

In total, this analysis suggests the significance of a trust-based ICT-driven disruptive business model (IDBM) with consolidated challenge for social demand (CCSD) for the development of cultural industries.

Section 2 of this paper analyzes the co-evolutionary development of the streaming and live music industries. Section 3 demonstrates a self-propagating function incorporating by the live music by assimilating its preceding digital innovations initiated by the digital music. The transformation of live music into a live-concert-streaming music industry is demonstrated in Section 4. Section 5 briefly summarizes noteworthy findings, policy suggestions and future research.

2. Co-evolutionary Development of the Streaming and Live Music Industries

In order to test the hypothesis developed in the preceding section, the correlational dynamism between the increasing popularity of streaming services and the boom of live music was analyzed, focusing on the period after the economic recession in September 2008, also called as the Lehman shock.

Fig. 5 shows the inducing role of streaming music in increasing the revenues from live music from July 2009 to December 2015, a time span we divided into six periods. Logarithmic monthly revenues (US$ million) of streaming music (explanatory variable) and live music (dependent variable) with one month time-lag for an explanatory variable were used for identifying causality. Coefficient dummy variables corresponding to the six periods were used (see Appendix 1 on data construction).

A similar analysis for the inducing role of live music in increasing the revenues from streaming music over the same periods was also conducted as demonstrated in **Fig. 6**.

Both analyses demonstrate statistically significant results (see the *Note* below the figures).

Effects and efficiencies of both inducements (inducement of live music revenues by streaming music and also of streaming music by live music) in each of the 6 periods are tabulated in **Table 2**.

When examining the figures and the table, we note the following behavior:

(i) While live music revenues declined after the economic recession due to the Lehman shock in September 2008 (periods D_1 and D_2), the trend changed to increasing from the late 2010 (period D_3) as streaming music commenced to induce live music revenues.

(ii) This inducement increased dramatically from the early 2013 (D_4).

(iii) Live music induced by streaming music in turn induced streaming music revenues with a one month time lag from the late 2010 onwards.

(iv) These revenue increases in streaming music induced by live music led to successive inducement of revenue increases in live music.

(v) Thus, the negative or the vicious cycle hanging over the correlation between the streaming music and live music industries converted to a co-evolutional relationship (mutually inspiring virtuous cycle) from the late 2010.

(vi) This co-evolution was further activated in the early 2013.

This co-evolutionary dynamism provides a reasonable explanation for the parallel paths of the increasing popularity of streaming services and the conspicuous growth of live music from 2010 on and its further acceleration since 2013 as observed in Fig. 3.

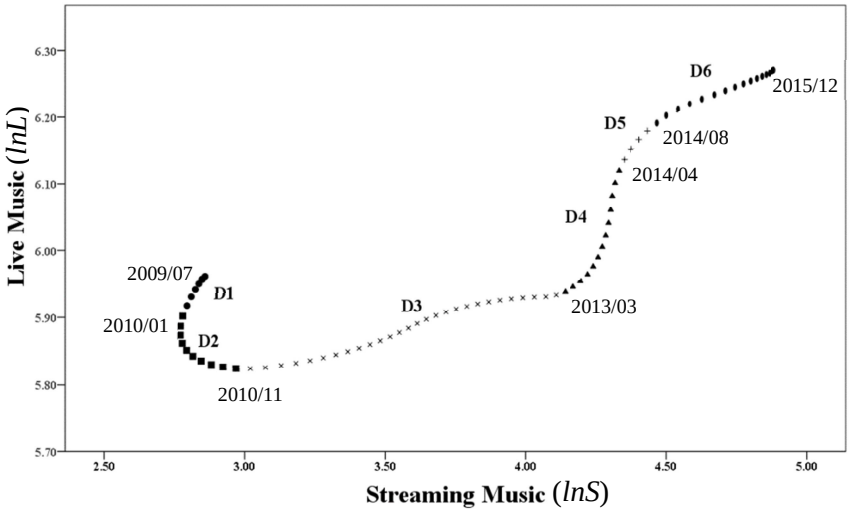


Fig. 4. Inducing Role of Streaming Music in Increasing Revenues from Live Music in the US *(Jul. 2009 – Dec. 2015)***.**

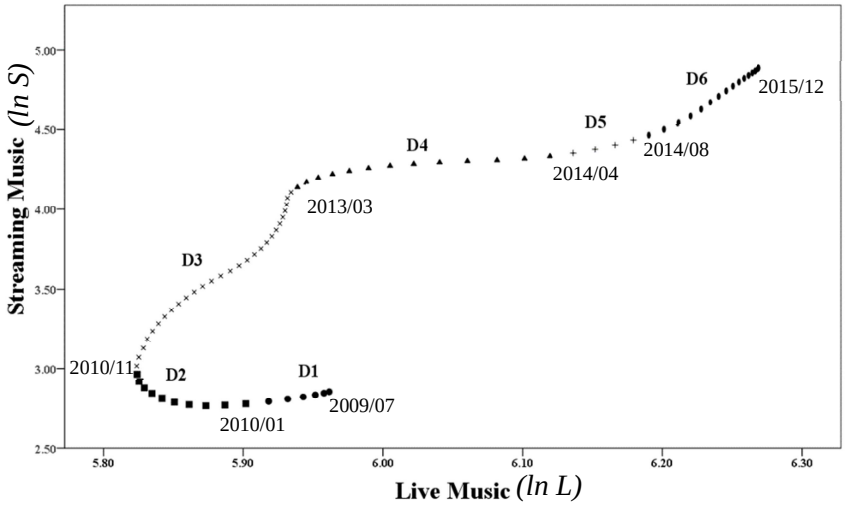


Fig. 5. Inducing Role of Live Music in Increasing Revenues from Streaming Music in the US *(Jul. 2009 – Dec. 2015)***.**

Note: **Regression analyses in Figs. 4 and 5**

$$\ln Y_t = \alpha + \sum_{i=0}^{6} [\beta_i D_i] \ln X_{t-1} \qquad (Y, X = L, S\,(Fig.4),\ S, L\,(Fig.5))$$

***L*:** Live music monthly revenue *(million US$)*, ***S*:** Streaming music monthly revenues *(million US$)*,

$D_{i=1-6}$: Dummy variables.

D_1: 2009.07 – 2009.12, rest = 0. D_2: 2010.01 – 2010.10, rest = 0. D_3: 2010.11 – 2013.02, rest = 0.
D_4: 2013.03 – 2014.03, rest = 0. D_5: 2014.04 – 2014.07, rest = 0. D_6: 2014.08 – 2015.12, rest = 0.

Correlation of Fig. 4 $\quad adj.\ R^2\ 0.993 \quad DW\ 1.05$

$$\ln L_t = \underset{(195.91)}{5.455} + \underset{(17.22)}{0.172} D_1 \ln S_{t-1} \underset{(-4.21)}{-0.365} D_2 \ln S_{t-1} + \underset{(15.43)}{0.121} D_3 \ln S_{t-1} + \underset{(14.50)}{0.837} D_4 \ln S_{t-1} + \underset{(24.54)}{0.161} D_5 \ln S_{t-1} + \underset{(28.13)}{0.167} D_6 \ln S_{t-1} + \underset{(5.80)}{1.426} D_2 \underset{(-12.13)}{-2.989} D_4$$

Correlation of Fig. 5 $\quad adj.\ R^2\ 0.992 \quad DW\ 1.04$

$$\ln S_t = \underset{(-26.59)}{-38.272} + \underset{(28.56)}{6.906} D_1 \ln L_{t-1} \underset{(-3.06)}{-1.844} D_2 \ln L_{t-1} + \underset{(29.09)}{7.121} D_3 \ln L_{t-1} + \underset{(3.29)}{0.971} D_4 \ln L_{t-1} + \underset{(29.64)}{6.944} D_5 \ln L_{t-1} + \underset{(29.88)}{0.6.894} D_6 \ln L_{t-1} + \underset{(13.63)}{51.917} D_2 + \underset{(16.07)}{36.700} D_4$$

The figures in parenthesis indicate *t*-statistics: all are significant at the 1% level**.**

Table 2 Elasticity of Co-evolution between the Streaming and Live Music Industry in the US *(Jul. 2009-Dec. 2015)*

		Elasticity		Remarks
		Streaming → Live	**Live → Streaming**	
D_1	***Jul.2009 - Dec.2009***	0.172	6.906	**Vicious cycle** (Both decrease)
D_2	***Jan.2010 - Oct.2010***	-0.365	-1.844	**Negative cycle** (Streaming increases, live decreases)
D_3	***Nov.2010 - Feb.2013***	0.121	7.120	**Virtuous cycle** (Both increase) ⇩ **Co-evolution**
D_4	***Mar.2013 - Mar.2014***	0.837	0.971	
D_5	***Apr.2014 - Jul.2014***	0.161	6.944	
D_6	***Aug.2014 - Dec.2015***	0.167	6.894	

Note: Elasticity of streaming *(S)* to live *(L)* ε_{LS} explains 1% increase in *S* increases ε_{LS} % increase in *L*, and represents the efficiency of *S* inducement of *L*. This elasticity corresponds to the slope of the Fig. 4.

Table 2 clearly demonstrates there was a conversion from the vicious and negative correlation between streaming music and live music into a co-evolutional relationship. This relationship emerged in the late 2010 and further accelerated from the early 2013.

Furthermore, it is suggested that this co-evolution may have enabled the live music assimilation of the preceding digital innovations accumulated in streaming music, which also assimilated its preceding innovations from downloading music.

3. Self-propagating Function Incorporated in Live Music Industry

This section was inspired by the findings obtained in the preceding section and the subsequent postulate that a co-evolutionary relationship between streaming music and live music exists, we built our model and tested it. It was further anticipated that this relationship might enable live music to assimilate of the preceding digital innovation accumulated in the streaming music. This set of innovation also assimilated the preceding innovation from downloading music. We expect to see that this assimilation would be a driving force for the resurgence of live music. This section analyzed the dynamics of this system.

The dynamics of assimilating the spillover technology can be summarized as follows (Watanabe et al., 2001):

(i) When coming across a flow of spillover technology, cumulative learning plays a decisive role. Cumulative learning cultivates the capacity to distinguish this flow by assessing and classifying it into *should learn*, *should not learn*, and *cannot learn* categories, resulting in certain absorptive capacity to adapt any accepted spillover technology to own technology stock, and

(ii) Through a co-evolutionary exercise of absorption, assimilation capacity can be developed to enable it to incorporate the absorbed technology into the whole innovation value chain as production, diffusion and utilization.

Fig. 6 illustrates the concept of assimilation of spillover technology in this dynamism. Assimilation capacity can be depicted as equation (1) (Watanabe et al., 2002).

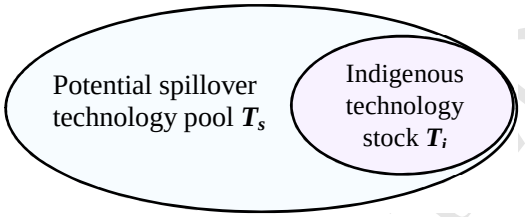


Fig. 6. Concept of Assimilation of Spillover Technology.

Assimilation capacity[4] $z = \dfrac{1}{1 + \dfrac{\Delta T_s}{T_s} \Big/ \dfrac{\Delta T_i}{T_i}} \cdot \dfrac{T_i}{T_s}$ (1)

In the case when live music assimilates the cumulative stock of the preceding digital innovation from streaming music, assimilation capacity and gross assets consisting of indigenous assets and assimilated assets can be depicted as equations (2) and (3), respectively.

$$z = \frac{1}{1 + \dfrac{\Delta T_d / T_d}{\Delta T_l / T_l}} \cdot \frac{T_l}{T_d} \quad (2) \qquad T = T_l + z \cdot T_d = \left(1 + \frac{1}{1 + \dfrac{\Delta T_d / T_d}{\Delta T_l / T_l}} \right) \cdot T_l \quad (3)$$

On the basis of this formula, trends in assimilation capacity and gross assets of live music in the US over the period of 2006 - 2015 were measured as demonstrated in **Figs. 7** and **8**.

[4] In the assimilation dynamism described, its capacity is a function of the ratios of volume and growth rate of the donor and the host. See the details of its mathematical development in Watanabe et al. (2002).

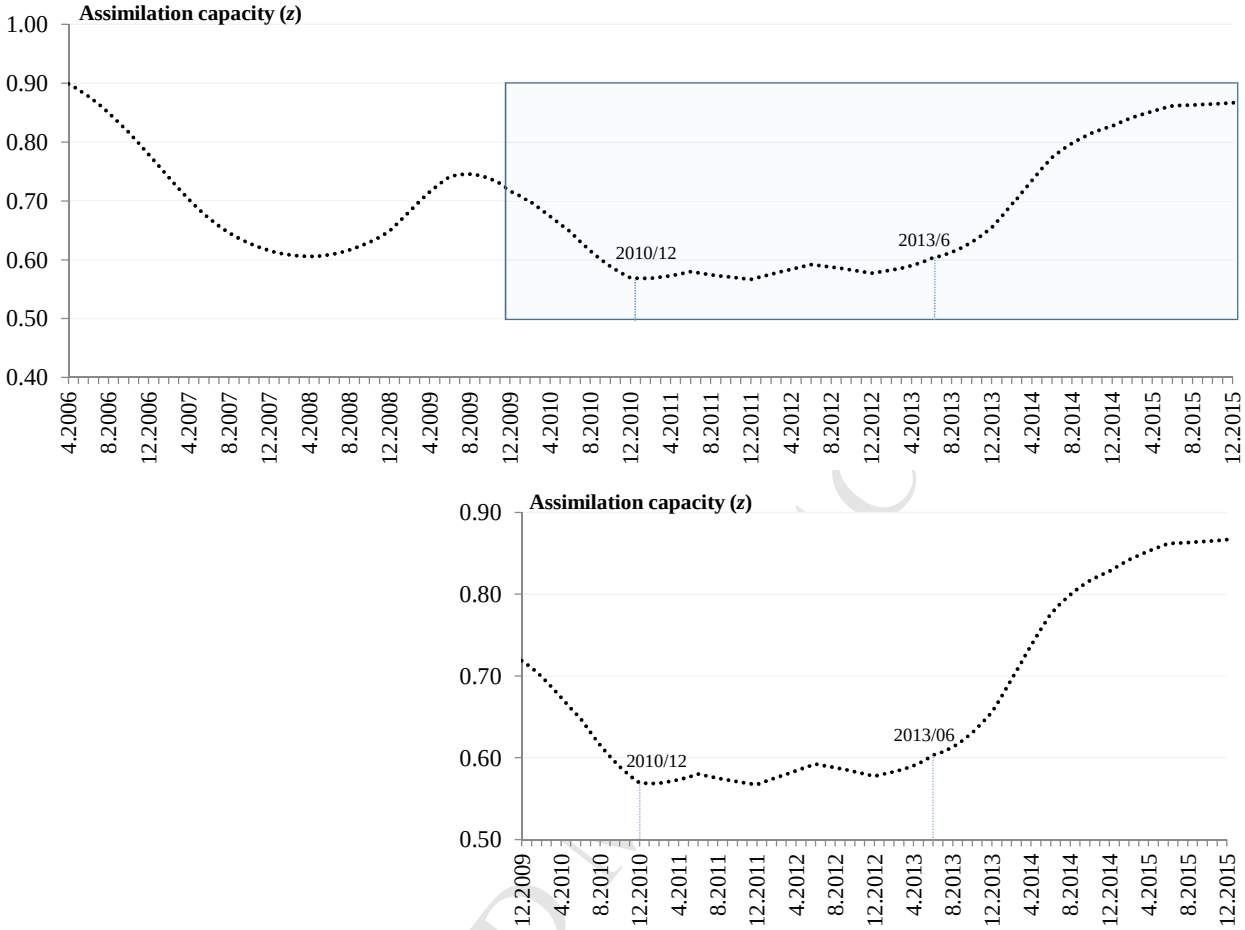


Fig. 7. Trend in Assimilation Capacity of the Live Music Industry in the US *(2006-2015)*
- 6 months moving average.

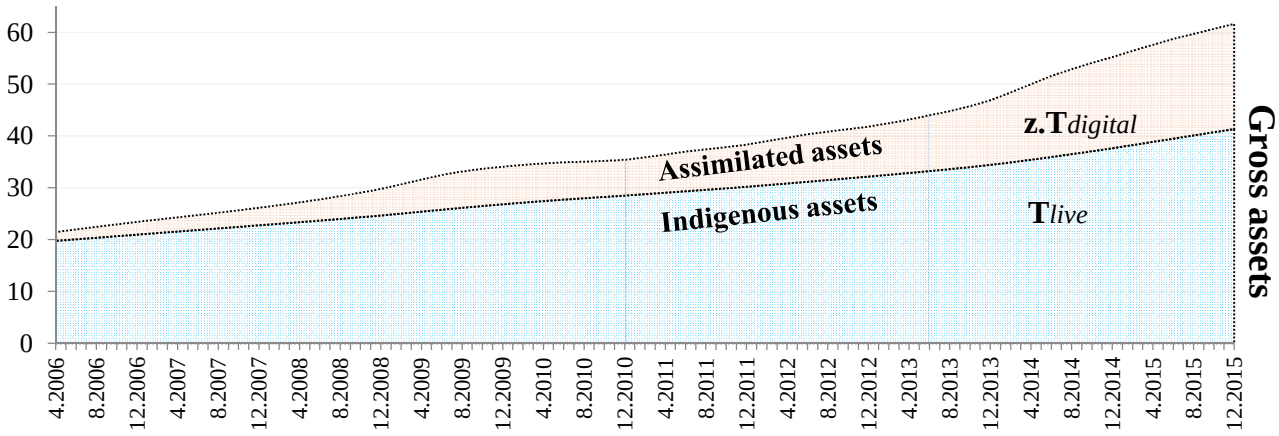


Fig. 8. Trends in Indigenous and Assimilated Assets in the US Live Music Industry[5] *(2006-2015).*

[5] ***Gross music assets*** $T = T_{live} + zT_{digital}$ *where* T_{live} : Live music assets, $zT_{digital}$: Assimilated assets from digital music.

Fig. 7 shows that while the assimilation capacity of live music, representing a general case of mature industries, continued to decline particularly after the economic recession in 2009, this changed to an upward trend from the late 2010 and dramatically increased from the middle of 2013. Both changes correspond to the beginning of the co-evolution with streaming music, with a few months' time-lag, as demonstrated in Fig. 4.

Supported by the dramatic increase in the assimilation capacity, the share of assimilated assets in live music has increased significantly, particularly since 2013, reaching up to 50% of its indigenous assets in 2015 as demonstrated in Fig. 8.

This significant assimilation of digital innovation from digital music through the co-evolution with streaming music enabled live music to incorporate a self-propagating function which enhances the functionality of live music. Enhanced functionality prolongs the lifetime of live music, leading to a lower obsolescence rate (see Appendix 3). This contributes to the increase in its revenues and assets as illustrated in **Fig. 9**.

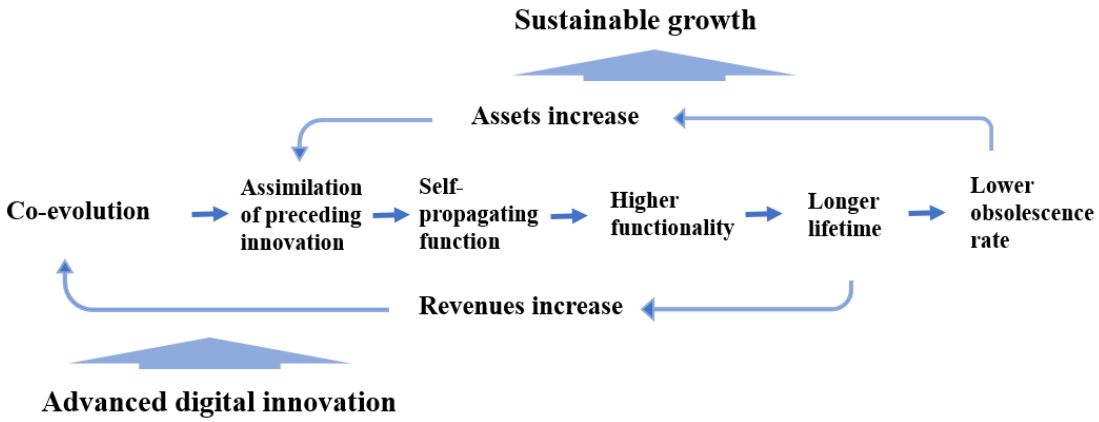


Fig. 9. Scheme for Sustaining the Resurging Trend of Music Industry.

With this dynamism in mind, in the above analysis the obsolescence rate of live music decreased to reflect the consequence of a "live-streaming phenomena" that started from 2010 and its subsequent activation of co-evolution (see Appendix 4). **Fig. 10** compares the level of assimilation capacity with the obsolescence rate decreasing effect (*ORDE*) does not function.

Fig. 10 demonstrates that the level of assimilation capacity decreases if *ORDE* does not function, thus supporting the dynamism illustrated in Fig. 9.

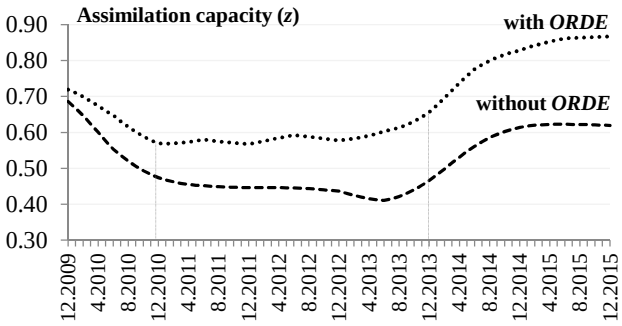


Fig. 10. Comparison of Assimilation Capacity with and without Reflecting Obsolescence Rate Decreasing Effect (*ORDE*).

Since logistic growth function within a dynamic carrying capacity (*LGDCC*) exhibits self-propagating behavior (Watanabe et al., 2004*a*, see Appendix 5 on this dynamism), LGDCC was utilized to demonstrate that self-propagating function in live music.

Table 3 compares the *LGDCC* of the assets of the live music industry over the period of January 2004 - December 2015 with the following asset conditions:

(i) Gross assets with *ORDE* ($T_l + z \cdot T_d$, ρ = 9 - 6.5%)

(ii) Indigenous assets with *ORDE* (T_l, ρ = 9 - 6.5%)

(iii) Gross assets without *ORDE* ($T_l + z \cdot T_d$, ρ = 10%) where ρ: rate of obsolescence of assets.

Table 3 Comparison of Self-propagating Function Incorporated in the US Live Music Industry *(Jan. 2004-Dec. 2015)*

LGDCC $Y(t) = \dfrac{N_k}{1+be^{-at} + \frac{b_k}{1-\frac{a_k}{a}} e^{-a_k t}}$

Live music assets condition	N_k	a	b	a_k	b_k	$adj.R^2$
(i) Gross assets with *ORDE*	148.189 (5.51)	0.179 (2.05)	1.725 (2.50)	0.010 (14.96)	6.912 (5.62)	0.993
(ii) Indigenous assets with *ORDE*	83.247 (5.75)	0.136 (3.23)	1.137 (3.66)	0.009 (9.97)	3.748 (5.26)	0.990
(iii) Gross assets without *ORDE*	141.417 (1.71)*	0.108 (4.12)	5.741 (1.63)*	0.009 (4.54)	5.992 (1.61)*	0.971

Y: assets of live music; N_k: carrying capacity; *t*: time; *a*, *b*, a_k, b_k: coefficients.
The figures in parenthesis indicate t-statistics: all are significant at the 1% level except *: 5% level.

Table 3 shows that (i) gross assets with *ORDE* are statistically more significant than (ii) indigenous assets with *ORDE* and (iii) gross assets without *ORDE*. In addition, the values of the factors governing dynamic carrying capacity ($\frac{b_k}{1-\frac{a_k}{a}}$) are 7.39, 4.01 and 6.53, respectively, which demonstrates that (i) gross assets with *ORDE* incorporate the self-propagating function most significantly.

Furthermore, by comparing (i) and (ii), it is demonstrated that live music has turned out to be incorporating the self-propagating function by assimilating the preceding digital innovations accumulated in digital music through the co-evolution with streaming music.

In addition, by comparing (i) and (iii), it is demonstrated that this self-propagation process follows the dynamism as illustrated in Fig. 9 and suggests the significance of the advanced digital innovations for sustaining and activating the co-evolution between live music and streaming music industries, resulting in a sustainable growth of the music industry.

These observations and models support our hypothesis.

4. Transformation into a "Live-concert-streaming Music Industry"

The analyses discussed in the preceding sections demonstrate that the recent noteworthy streak in the resurgence of the US music industry can be attributed to the co-evolution between the streaming music and live music industries and their assimilation of preceding innovations.

Given this long-awaited resurgence of the music industry in mind, our concerns goes to whether the co-evolution is based on a sustainable structure or a transient phenomenon.

In order to address this concern, this section analyzed the structure governing the future trends in the respective music industries and the tasks to be carried out to maintain the co-evolution of live music and digital music initiated by streaming music.

4.1 Structure Governing the Trends in the Music Industry

Trends in music entering the market, as well as its assets there are normally subject to an epidemic function. However, these are sensitive to changes in external circumstances such as customer's preferences and the emergence of competitive businesses and innovations in music industry.

With this peculiar nature, trends in music industry can be depicted by the following hybrid logistic growth model[6]:

$$Y = \frac{N_X}{1 + b_{X1} D_1 e^{-a_{X1} D_1 t} + b_{X2} D_2 e^{-a_{X2} D_2 t}} \qquad (4)$$

where Y: Music input into the market/its assets; N_x: Upper limit of diffusion (carrying capacity); X: P (physical music), D (digital music), L (live music); D_i: dummy variables corresponding to the change in external circumstances; t: time trend; and a_{Xi}, b_{Xi} (i = 1, 2): coefficients.

(1) Trends in Revenues in Music Industry Segments

By utilizing this model, monthly trends in revenues of physical music, digital music and live music over the period of January 1985 – December 2015 were estimated, and the fitness of the estimated trends with actual trends was evaluated first.

The estimated trends are illustrated in **Figs. 11–13**, and the results of the fitness evaluation are summarized in the *Note* on the Figures, which demonstrates an extremely high level of fitness as the value of *adj*. R^2 is higher than 0.95 and 1% significance level of t statistics of all coefficients in all cases analyzed.

With this confirmation of reliability, Figs. 11-13 also illustrate the estimated future prospects of the revenues toward 2030 in three industry segments.

[6] *HLG* model (Watanabe Naveed model). See Appendix 6.

1) Physical Music

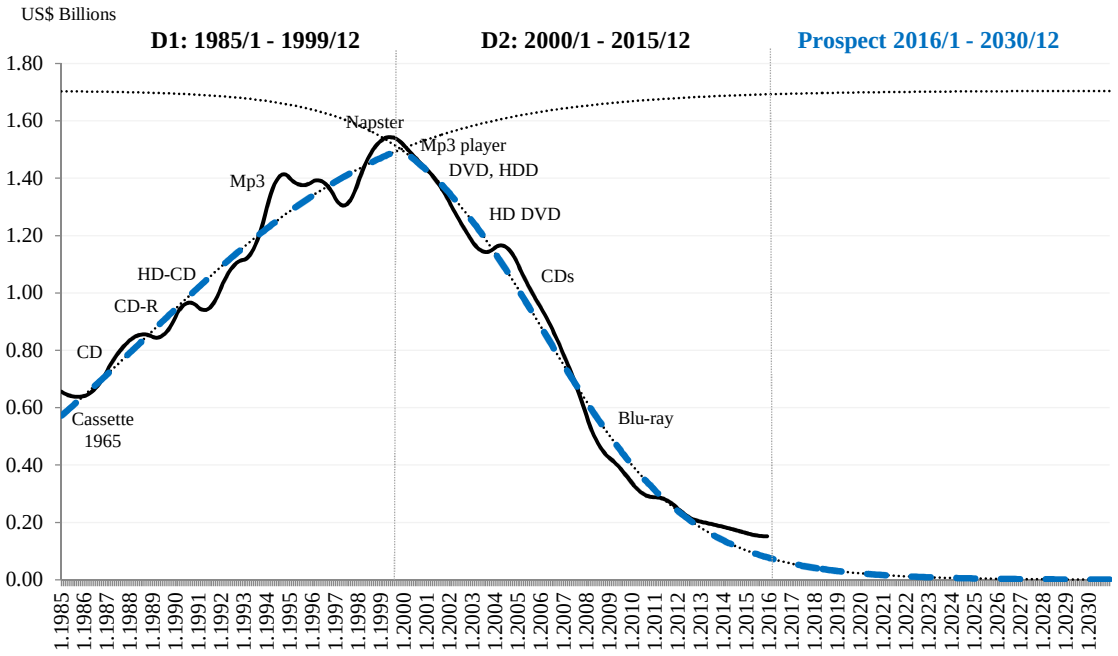


Fig. 11. Trend and Prospect of the Physical Music Revenues in the US *(1985-2030)***.**

2) Digital Music

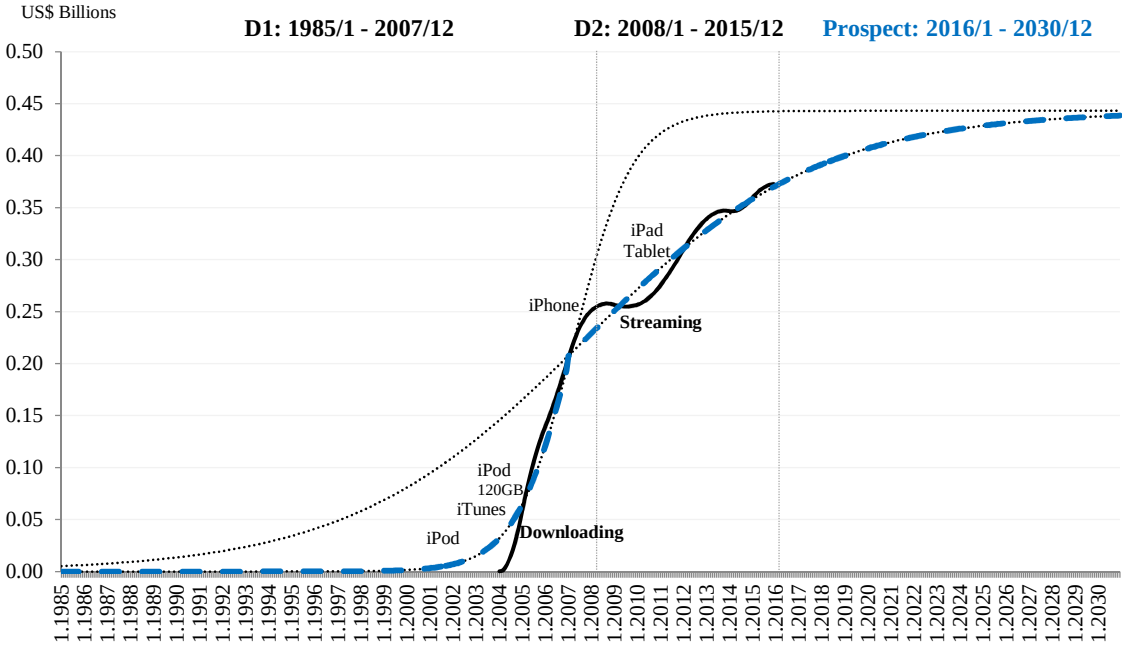


Fig. 12. Trend and Prospect of the Digital Music Revenues in the US *(1985-2030)***.**

3) Live Music

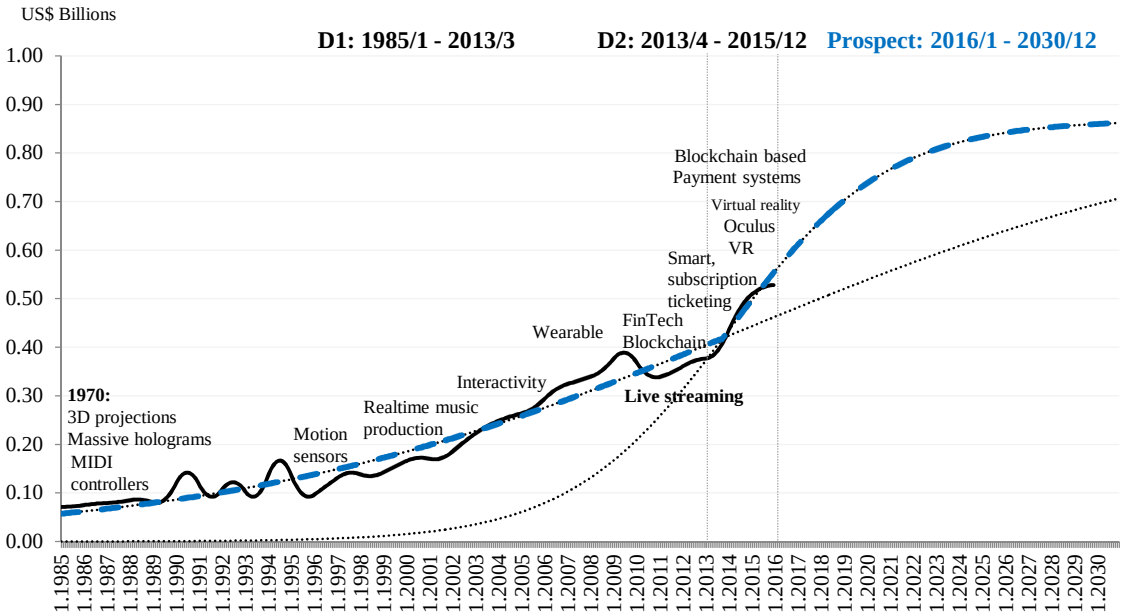


Fig. 13. Trend and Prospect of the Live Music Revenues in the US *(1985-2030)***.**

Note*: Regression analyses for Figs. 11-13** *(Jan. 1985 -Dec. 2015).**

$$Y = \frac{N_X}{1 + b_{X1} D_1 e^{-a_{X1} D_1 t} + b_{X2} D_2 e^{-a_{X2} D_2 t}}$$

	N_X	D_1		D_2		adj. R^2
		a_1	b_1	a_2	b_2	
		1985/1 - 1999/12		*2000/1 - 2015/12*		
Physical	1.705	0.015	1.980	-0.026	0.001	0.983
	(60.89)	(15.00)	(28.46)	(-26.00)	(-36.76)	
		1985/1 - 2007/12		*2008/1 - 2015/12*		
Digital	0.443	0.066	42.08 x 10^6	0.016	84.775	0.981
	(14.29)	(22.00)	(21.51)	(5.33)	(6.97)	
		1985/1 - 2013/3		*2013/4 - 2015/12*		
Live	0.868	0.007	14.145	0.024	41.123 x 10^2	0.966
	(7.54)	(19.75)	(23.32)	(5.48)	(6.41)	

N_X: Carrying capacity, t: Monthly trend, a_1, a_2, b_1, b_2: Coefficients, D_1, D_2 dummy variables.
Figures in parenthesis indicate t-statistics: all are significant at the 1% level.

(2) Future Prospects of the Music Industry as a Whole

Based on the preceding analysis of the trends and prospects of the three music industry segments, the future prospects of the music industry as a whole were examined next.

Given that the foregoing structure governing each respective music industry in the US continues, **Fig. 14** demonstrates the estimate on the US music industry's future prospects towards 2030 by simply summing up the estimates of the future prospects of each of the music industries.

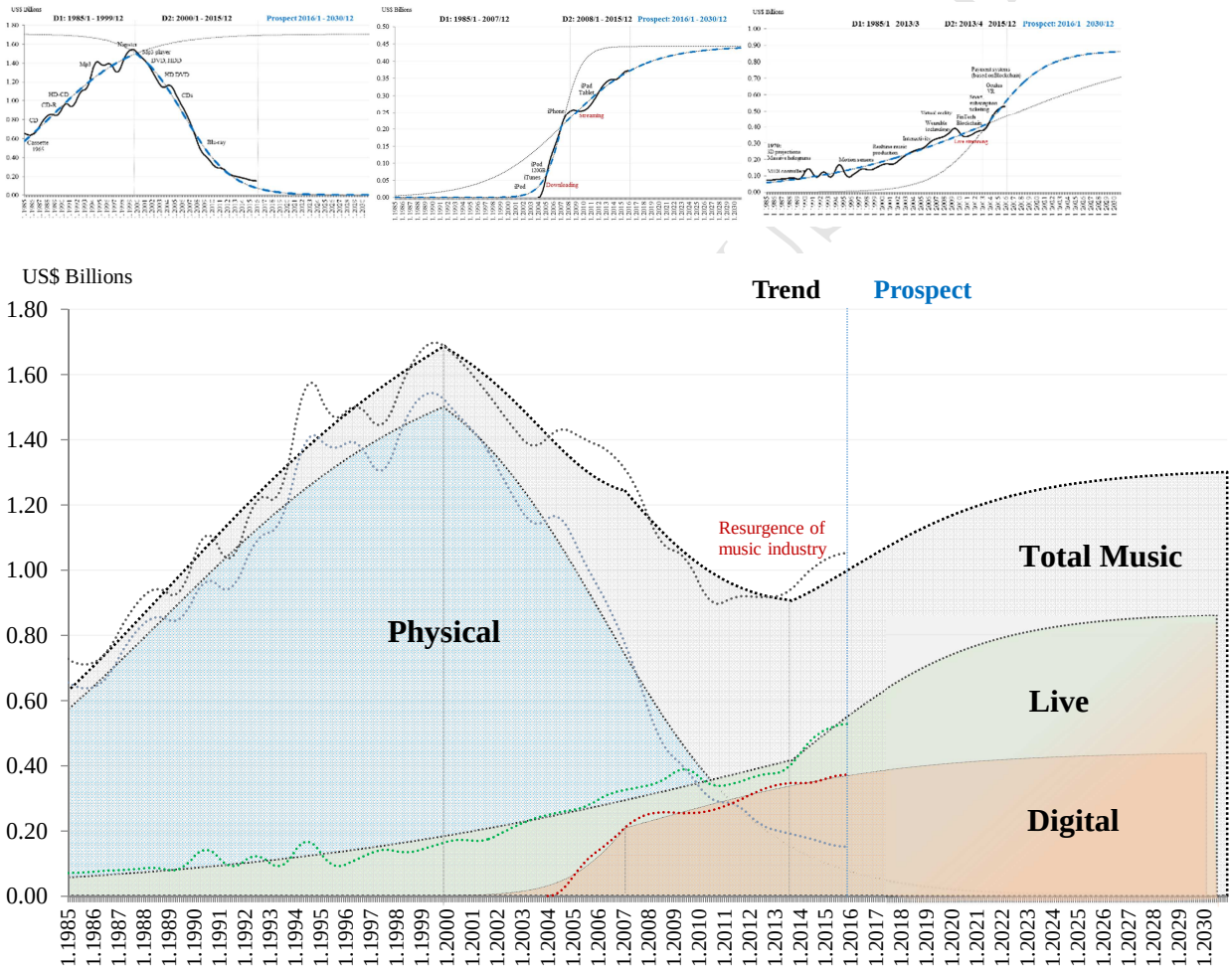


Fig. 14. Trends and Future Prospects of the US Music Industry.

January 1985- December 2015: Trend, *2016 – 2030:* Prospect.

Fig. 14 demonstrates that the improving trends in live music continuing together with a slight increase in digital music, leading to a resurgence of the music industry as a whole from its lowest point in the early 2010s. As analyzed earlier, the parallel paths of the increasing trends in both live music and digital music can be attributed to the co-evolution between streaming music and live music. These findings suggest how to sustain this co-evolution, which could be the key strategy for the resurgence of the music industry.

(3) Sustainability of the Resurging Trends

While the prospect of a resurgence in Fig. 14 is based on the resurging trends chiefly in live music and digital music, streaming music is drawn by their co-evolution. It should be noted that the co-existence of two sectors in the same industry does not necessarily mean co-evolvement; sometimes it is a case of a substitution of one for the other and may result in killing the partner as in the case of downloading and streaming music.

Although the identification of the dynamism of such reactions of the three music industry segments is beyond this analysis, the results of the preceding analyses give us some confidence to believe that by activating and sustaining the co-evolution between live music and streaming music there will be a way towards the sustainability of the resurging trend in the music industry, as illustrated in Fig. 9.

With this confidence, the last analysis of this paper focuses on possible strategic options for activating the above co-evolution..

4.2 Transformation of Music Industries for Sustainable Co-evolution

The above analyses suggest that the stakeholders involved in music industry have undergone structural changes, which inevitably drive disruptive changes in the business model of the industry.

The relationship between music fans (consumers) and other actors in the music business is also changing. Instead of owning CDs or other types of music embedded in physical media released by particular artists, fans now want an access to a widening choice of music. The change from ownership to access brings fans closer to the artist and transforms the role of commercial actors (or enablers) such as record labels (Erica, 2016). As the music industry has moved from a product to a service business model, the loss of sales does not necessary reflect losing customers (Parry et al., 2012).

We have sought to move our focus from fans undermining the music industry through piracy to fans enhancing and co-creating value in partnership with artists and small record labels. Evidence is now emerging that the Internet is enabling some record labels, artists and fans to work together to co-create value for mutual benefits (Choi et al., 2013). These participants work in the concert production through co-creation, interaction and participation in all phases of the production. By harnessing innovative technology, the participants can engage in co-creating memorable live concert experiences (Erika, 2016), and advancement of the Internet further promotes such participative creativity (Choi et al., 2013).

Live shows, which are something fans cannot fully experience online, have become increasingly valuable for both fans and artists, the market concert tours being the primary source of revenue for most artists.

While these dynamics have created a renaissance of live music, the value chain is incredibly complex, with multiple stakeholders taking their share (e.g., ticketing, secondary ticketing, venues, booking agents, promoters, tax and expenses). The share of the revenue that artists make from live music has declined every year since 2000. The

ICT-driven disruptive business model (IDBM) is needed to transform that complex chain into a new more straightforward productive chain.

Under these circumstances, the only thing record labels, artists, music publishers and consumers can do is embrace the new technologies and allow the digital age to work to the advantage of everyone, with the hope that the wonderful art which we call music will keep its integrity for all of eternity (Stafford, 2010). Technological tools are becoming increasingly sophisticated, and the collaborative cultural landscape continues to evolve (Freeman, 2010).

Thus, new business opportunities, particularly in the areas of digital distribution and live entertainment, will likely take the center stage as the progression of the Internet continues (El Gamal, 2012). The ICT-driven disruptive business model (IDBM) consolidating the advantage of digital music into live music has raised all stakeholders' expectations. This supports the significance of co-evolution between streaming music and live music as demonstrated in the preceding analysis and suggests a leading role for the ICT-driven "live-concert-streaming music industry" (*LCSMI*) as the savior of the music industry.

Based on the review above, **Fig. 15** illustrates the direction of the music industry towards a sustainable resurgence. This corresponds to the way of constructing a trust-based IDBM (ICT-driven disruptive business model) with CCSD (consolidated challenge for social demand) as has been demonstrated in the new stream of sharing economy like that initiated by Uber's ride-sharing revolution (Watanabe et al., 2017*a*).

Fig. 15 highlights the specific features of "live-concert-streaming music industry" (*LCSMI*) that correspond to the following historical demand through co-evolution between the streaming and live music industries:

(i) Historical change in consumers propensity to music from *viewership* → *physical ownership* → *digital ownership* → *access* → *viewership and access*,

(ii) Shift in consumers preferences from passive listeners or viewers to access to widening choice of music, participation, integration, co-creation, and participative creativity,

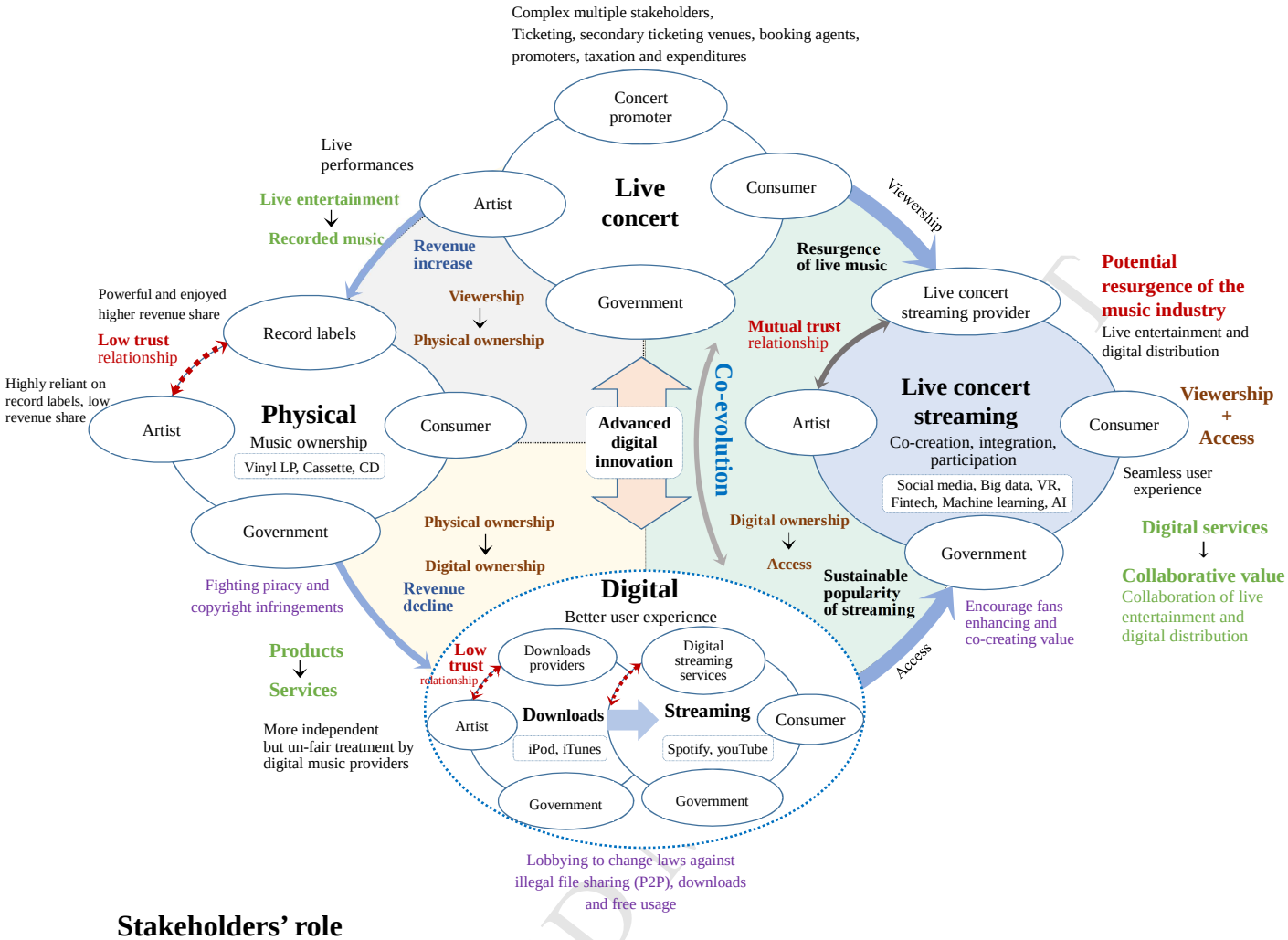
(iii) Emergence of the collaborative cultural landscape,

(iv) Collaboration of live entertainment and digital distribution, and

(v) Long-lasting desire of consumers as well as organizers to transform live music's complex chain with multiple stakeholders into plain productive chain.

Advanced digital innovation, such as social media, big data, virtual reality, fintech, machine learning and artificial intelligence, has enabled the sustainability and activation of this co-evolution.

It should be noted that this co-evolution can be attributed to increasing trust among stakeholders supported by the overdrawing of the past information (Luhmann, 1979) and also by implementing the emerging technologies such as blockchain.



Stakeholders' role

	Company	Employee (Artist)	User (Consumer)	Government
Live concert	**Concert promoter:** the individuals or companies responsible for organizing a live concert tour or special event performance. e.g., Live Nation & Ticketmaster.	**Tour artist:** The tour promoter signs an employment or live performance contract with particular artists to perform in live concerts.	**Fans/attendee:** The individual who attend the live concert or performance.	Event promotion, licensing, noise restrictions, security requirements.
Physical	**Record label:** It coordinates the production, manufacturing, distribution, marketing, promotion and enforcement of copyrights for sound recordings and music videos.	**Recording artist: A** singer, musician who records music, or who fills in missing musical parts on a song. A pop music star or a rapper who has a contract with a record label is an example of a recording artist.	**Physical music consumer:** Buy physical music goods (LPs, Cassettes, CDs etc.) for ownership rather than for resale or use in the production and manufacturing?	Fighting piracy and copyright infringements
Digital	**Digital music provider:** The companies who provide digital music downloading and streaming services such as iTunes, Amazon, Spotify, youTube.	**Artist:** It includes recording and independent artists, whose music is available for downloading and streaming through digital music provider companies or directly.	**Digital music Consumer:** Who download digital music or listen through online streaming services.	Lobbying to change laws against illegal file sharing (P2P), downloading and free usage.
Live concert streaming	**Live streaming concert provider:** the services that offer the live streaming of the concerts as an alternative to be physically present in the concerts.	**Artist:** By live concert streaming services the artists' live concerts can engage viewers from remote locations. The technologies such as virtual reality provide lot of opportunities.	**Virtual participant:** The consumers who are unable to attend live concerts physically and they choose to participate virtually through live concert streaming services.	Encourage fans enhancing and co-creating value.

Fig. 15. Concept of IDBM with CCSD in the Music Industry – Live-Concert-Streaming Music Industry (*LCSMI*).

This direction corresponds to a new stream of innovation: spinning off from traditional to new co-evolution of the advancement of ICT with un-captured GDP dependency and shift to what is called "supra-functionality beyond economic value", has been demonstrated in the digital economy such as in Uber's ridesharing revolution and the digitally-rich innovative learning environments (Watanabe et al., 2015*b*, 2016*a*, 2016*b*, 2017*a*, 2017*b*) are illustrated in **Fig. 16**.

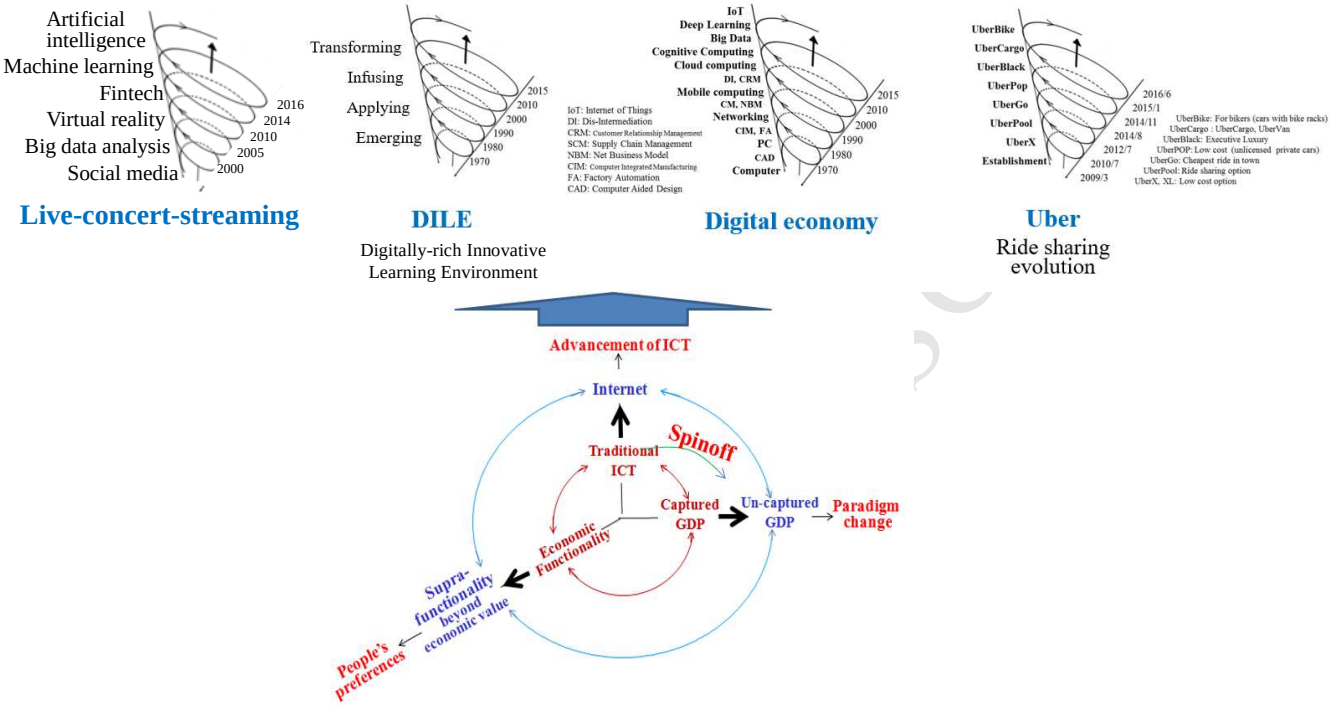


Fig. 16. Music Industry in the Spinoff Dynamism.

This new stream of innovation impulses the resurgence of the music industry in a self-propagating way as illustrated in **Fig. 17,** which in turn demonstrates a testbed for a resurgence strategy for cultural industries.

Artificial intelligence	Creation of algorithms enabling the creation of customized songs for users and helping artists to focus more on being creative.
Machine learning	Enabling consumers to draw on past information, leading to increasing trust among stakeholders.
Fintech	The rise of the blockchain and bitcoin creating new methods of sharing, creating and selling music.
Virtual reality	Interactive virtual worlds created by artists to allow fans from all over the world to share experiences and open up new worlds, enabling also disabled (financially and physically) people to enjoy live music.
Big data analysis	Providing sources for real-time personalization by compiling wide-ranging personal information (e.g., purchasing history, listening habits, physical and mental conditions).
Social media	Used for exploring new distribution channels (e.g., Facebook, Twitter, You Tube)

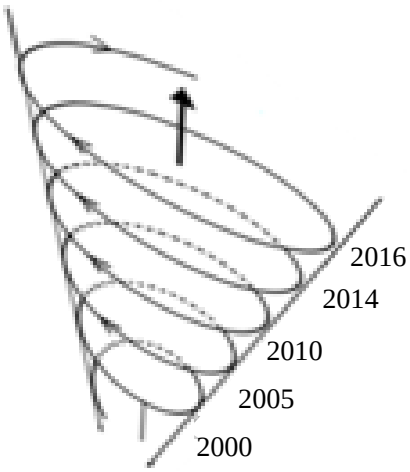


Fig. 17. Digital Innovation Supportive to Sustainability of Music Industry Resurgence.

5. Conclusion

This analysis shows that the recent resurgence of live music in parallel with the increasing popularity of streaming services could effectively save the music industry. The industry which is on the brink of an impending collapse due to diminishing revenues as a consequence of digitization. We pursued our analysis based on the possibility that the live music has effectively assimilated digital innovation from digital music through its co-evolution with streaming music.

An empirical analysis of monthly trends in the US music industry by sectors over the last three decades were conducted and revealed:

(i) A co-evolution between the streaming and live music industries has functioned well over the last few years,

(ii) The live music industry has incorporated a self-propagating function by assimilating its preceding innovations initiated by digital music,

(iii) Given the co-evolution between the streaming and live music industries, the recent resurging trend in the music industry can be sustained,

(iv) The advancement of digital innovation such as artificial intelligence, machine learning, fintech, virtual reality, and big data has enabled the sustainability and activation of this co-evolution while leading the live music industry to transform into a "live-concert-streaming music industry" (*LCSMI*) that enables participative creativity for all stakeholders,

(v) *LCSMI* corresponds to the historical demand of consumers as *a)* the consumers' propensity has shifted from viewership to physical ownership, digital ownership, access to viewership and access, *b)* consumers' preferences has shifted from passive listening or viewing to access to widening choice, participation, integration, co-creation, and participative creativity, *c)* emergence of collaborative cultural landscape, *d)* collaboration of live entertainment and digital distribution, and *e)* transformation of the complex chain of live music with multiple stakeholders into a more straightforward productive chain.

(vi) In this collaborative cultural environment the importance of trust among participating stakeholders (e.g. artists, music providers, ticket sellers, consumers etc.) has become even more crucial. The importance of trust together with the above points in turn suggest the significance of a trust-based ICT-driven disruptive business model (IDBM) with consolidated challenge for social demand (CCSD) for the successful development of our cultural industries

These findings give rise to the following insights about sustainable growth of the music industry:

(i) Establishment of a platform where streamed music services would participate with live music so as to construct a co-evolutionary relationship between them,

(ii) Participative creativity of stakeholders should be nourished,

(iii) Experiences of the preceding trust-based IDBM with CCSD initiatives in the sharing economy such as Uber's ridesharing revolution provide lots of learning opportunities,

(iv) The digitization of music and co-evolution of streaming and live music is very crucial and important step but it also needs an additional layer of trust to function successfully in a very collaborative environment. The implementation of emerging technologies e.g. blockchain distributed ledger might be helpful to further increase the transparency and visibility, building trusted relationships among the stakeholders of value chain.

(v) Active introduction of advanced digital innovations should be initiated by providing a testbed for the advancement of such innovations, and

(vi) Next generation of "live-concert-streaming music industry" (*LCSMI*) should be envisioned.

This paper explored a possible blueprint for the future of the music industry and provided a prototype of a dynamic system called the trust-based IDBM with CCSD for the further development of cultural industries. The historical demand for these systems can be applied not only to the music industry but also to other broader cultural industries, and lessons from the music industry can provide helpful guidelines.

Further research should focus on in-depth analysis of country-specific institutional systems accelerating the co-evolution between live music and streaming music industries. Further analysis of the optimal introduction of advanced digital innovations should be undertaken. For that, a wider empirical analysis covering more countries should be considered.

Given that the economic implications of this analysis are generally applicable to other similar industries as well, the analyses for the resurgence strategies for industries facing collapse such as print media industries could be helpful in understanding these dynamics and planning for the future.

Acknowledgement

The research leading to these results has received funding from the Strategic Research Council at the Academy of Finland under grant agreement 293446 – Platform Value Now: Value capturing in the fast emerging platform ecosystems.

Appendix 1 Data Construction

Revenues from the music industries (≈ net shipments estimated by monetary value)[7] can be considered as music input (live and recorded music, respectively) into the market while cumulative stock of the revenues can be considered as music assets in the market (Meade et al., 2006, Modis, 2007).

Therefore, the monthly trends in revenues and their cumulative stocks of live and recorded (physical and digital) music industries in the US over the period 1950-2015[8] were constructed as follows:

(1) Data collection

Annual revenue statistics available in current US$ (nominal value) over the period of 1974-2015 (for live and physical music) and 2007-2015 (for digital music) were collected.

(2) Estimation of missing data for unavailable years

Missing data for unavailable years (1950-1973 for live and physical music and 2004-2006 for digital music) was estimated by a forward and backward ensembles approach.

(3) Conversion to fixed prices

The annual revenues in current US$ were converted to fixed US$ (real value) by using the GDP deflator (base year = 2010).

(4) Disaggregation of annual data to monthly data

Since the life time of digital music is 12 years (2004-2015), in order to conduct significant time series analysis, all annual data were disaggregated to monthly data by using the Denton-Cholette temporal disaggregation method (Sax et al., 2013).

(5) Cumulative stock

Utilizing the above monthly revenues in fixed prices, cumulative stocks were estimated with the following equation. Annual obsolescence rate was estimated as 10% (0.83% per month)[9]. The details of the estimation of the obsolescence rate can be seen in Appendix 2.

Cumulative stock at time t $T_t = R_{t-m} + (1-\rho)T_{t-1}$ where R_t is revenues at time t, m (lead time for commercialization $\approx$ 0), and ρ is the rate of obsolescence of music assets (see Appendix 2). See Appendix 4 for estimated cumulative stock.

[7] Revenues = Sales + Interest income + Dividend income
Shipments (by monetary value) = Sales + Inventories
Revenues = Shipments – Inventories + Interest income + Dividend income ≈ Shipments

[8] In order to estimate the initial values for cumulative stock estimate, year 1950 was considered reasonable for live and physical music and 2004 for digital music (See Fig. 1).

[9] After the live-streaming phenomena emerged in 2010, the effects of functionality increases on the decreasing the rate of obsolescence value were taken into account (see Appendices 2 and 3).

Appendix 2 Rate of Obsolescence of Music Assets

Innovation becomes obsolete when it loses functionality (Barreca, 1998, Watanabe et al., 2009, Jennings et al., 2016). Thus, companies' efforts for sustainable growth correspond to the prolongation efforts of functionality development (Watanabe et al., 2009). Here, functionality is defined as ability to improve the performance of production processes, goods and services by means of innovation (Watanabe et al., 2004*b*) and corresponds to potential capacity before reaching the obsolescent stage (Watanabe et al., 2009). Innovation life-cycles can be measured by the period between the emergence and obsolescence of a phenomenon by its losing functionality (Barreca, 1998, Jennings et al., 2016). The average rate of obsolescence of an innovation can be estimated by taking the reverse of the length of this period.

Contrary to what applies to technology innovation, the concept of obsolescence of music assets is rather complicated. It is subject more strongly to cultural, economic and technology values. It varies depending on such institutional factors as the historical era, cohort, generation, fashion, handling practice, free music monster and piracy (Bylin, 2009). However, Peterson (1975) identified the existence of cycles in popular music and Cross (2012) demonstrated that these cycles in the US in the latter half of the last century can be estimated to last for approximately 10 years: Cycle 1: 1951-1963 (*Rok'n'roll*), Cycle 2: 1964-1975 (*Beatles*), Cycle 3:1976-1989 (*Disco storm to classic rock*), and Cycle 4: 1990-2002 (*Rock's next rebirth*).

These cycles correspond to the focus of academic research in musicology, and bibliometric analyses on the obsolescence of music literature have provided supportive evidence (Diadato et al., 1993). Bhattacharjee et al. (2007) discovered that, while digital sharing technologies shorten the survival time of low-ranked albums, they do not hurt the survival of top-ranked albums.

With an understanding that popular music accounts for majority of sales in music industry, these cycles represent the period between the emergence and obsolescence of functionality of music assets measured by cumulative stock of music industry revenues.

By taking the reverse of the above cycles' length, the foregoing reviews suggest 10% p.a. as a reasonable average rate of obsolescence for music assets. In addition, since the length of these cycles prolongs as functionality increases (Watanabe et al., 2009, see Appendix 3), the live-streaming phenomena that emerged in 2010 led to a decrease in the rate of obsolescence.

Appendix 3 Functionality, Lifetime and Obsolescence of Innovation

Logistic Growth Function within Dynamic Carrying Capacity (*LGDCC*) can be approximated by the Simple Logistic Growth Function (*SLG*) as follows:

$$
\begin{aligned}
Y &= \frac{N_k}{1+be^{-at}+\frac{b_k}{1-\frac{a_k}{a}}e^{-a_k t}} \\
&= \frac{N_k}{1+be^{-at}\left(1+\frac{b_k/b}{1-\frac{a_k}{a}}e^{(a-a_k)t}\right)} \\
&\approx \frac{N_k}{1+be^{-at}e^{\frac{b_k/b}{1-a_k/a}\cdot(1+(a-a_k)t)}} \\
&= \frac{N_k}{1+be^{\frac{b_k/b}{1-a_k/a}}e^{-a\left(1-(b_k/b)\right)t}} \\
&\approx \frac{N_k}{1+b\left(1+\frac{b_k}{b}\cdot\frac{1}{1-a_k/a}\right)e^{-a\left(1-(b_k/b)\right)t}} \\
&\equiv \frac{N_k}{1+b'e^{-a't}} \quad where \quad a'=a\left(1-\frac{b_k}{b}\right), b'=b\left(1+\frac{b_k}{b}\cdot\frac{1}{1-\frac{a_k}{a}}\right)
\end{aligned}
$$

Functionality can be depicted as follows:

$$FD=\frac{N_k}{Y}=1+b\left(1+\frac{b_k}{b}\cdot\frac{1}{1-\frac{a_k}{a}}\right)e^{-a\left(1-(\frac{b_k}{b})\right)t}$$

Its initial level is described as follows:

$$FD_0=\frac{N_k}{Y_0}=1+b\left(1+\frac{b_k}{b}\cdot\frac{1}{1-\frac{a_k}{a}}\right)$$

Thus, functionality, lifetime and obsolescence of innovation can be illustrated as follows (Watanabe et al., 2009):

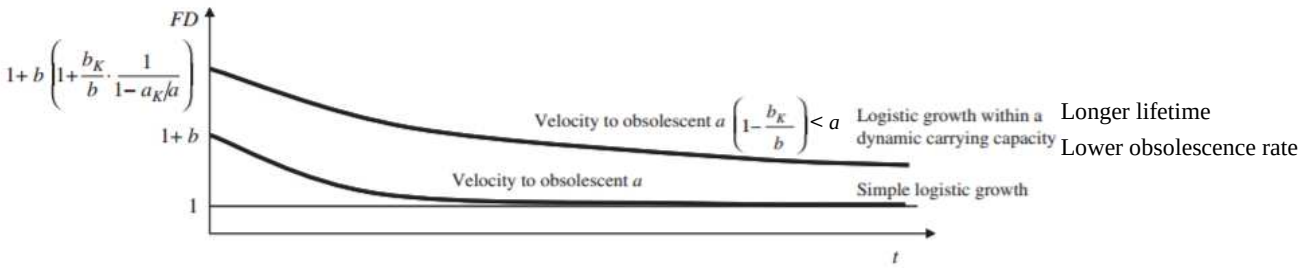
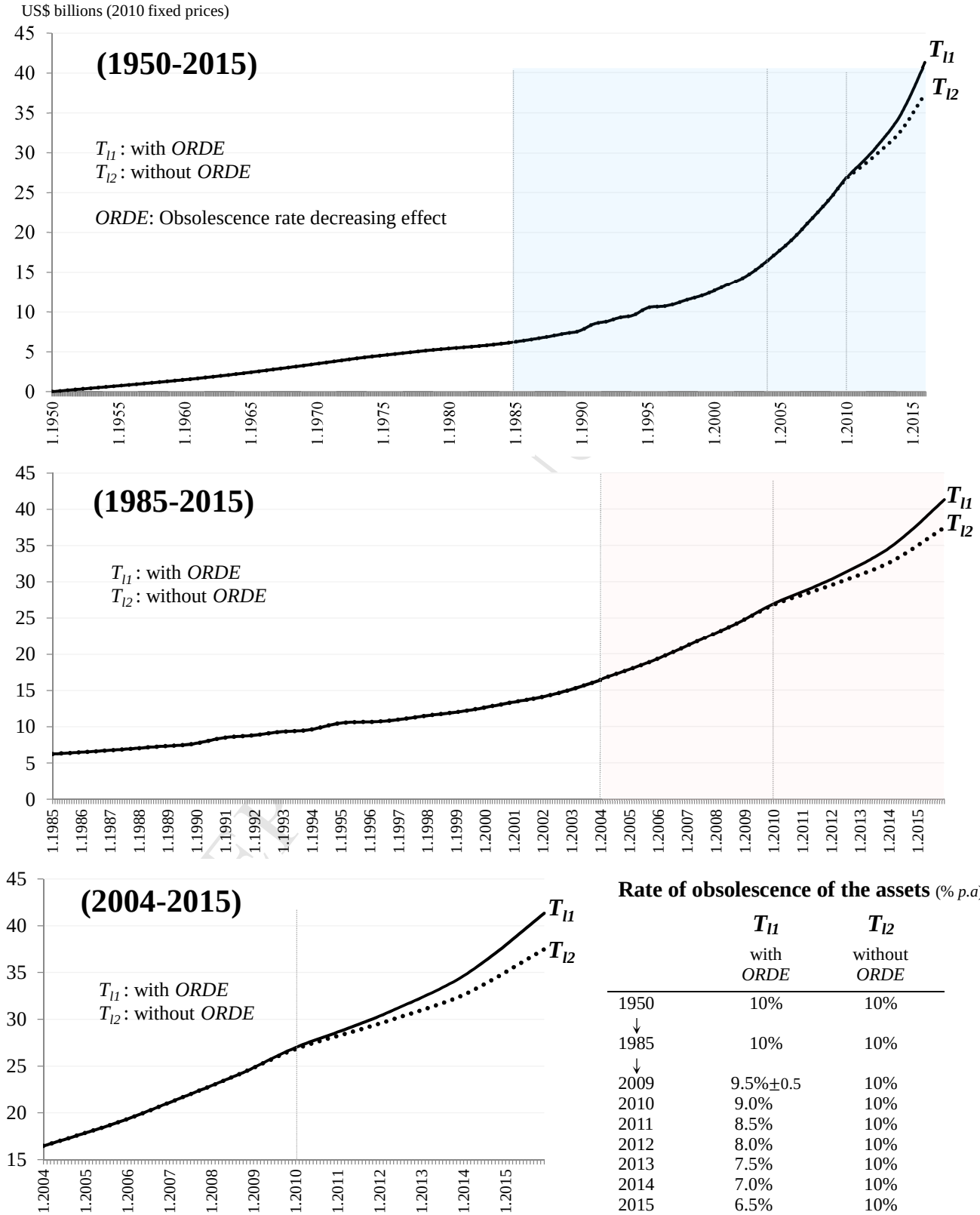


Fig. A1. The Scheme of Functionality, Lifetime and Obsolescence of Innovation.

Appendix 4 Assets Estimate for the US Live Music Industry *(1950-2015)*

Two cases, with or without obsolescence rate decreasing effect (*ORDE*), from 2010 were estimated.



Rate of obsolescence of the assets (% *p.a*)

	T_{l1} with *ORDE*	T_{l2} without *ORDE*
1950	10%	10%
↓		
1985	10%	10%
↓		
2009	9.5%±0.5	10%
2010	9.0%	10%
2011	8.5%	10%
2012	8.0%	10%
2013	7.5%	10%
2014	7.0%	10%
2015	6.5%	10%

Fig. A2. Trend in Live Music Assets in the USA - Cumulative Stock of Live Music Revenues.

Source: Pollstar (Year End Business Analysis Edition, 2015).

Appendix 5 Dynamism in Developing Self-propagating Function

Diffusion trajectory of innovative goods *Y* **Simple Logistic Growth (*SLG*) with fixed carrying capacity *(N)***

$$\frac{dY(t)}{dt} = aY(t)(1 - \frac{Y(t)}{N}) \quad \Rightarrow \quad Y(t) = \frac{N}{1 + be^{-at}}$$

Particular innovation which create new *N* during the process of diffusion.

Logistic Growth within a Dynamic Carrying Capacity (*LGDCC*)

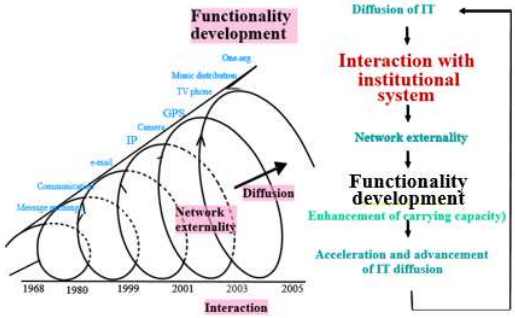
$$\frac{dY(t)}{dt} = aY(t)(1 - \frac{Y(t)}{N(t)}) \quad \Rightarrow \quad Y = \frac{N_k}{1 + be^{-at} + \frac{b_k}{1 - a_k / a} e^{-a_k t}}$$

Carrying capacity increases as *Y* increases.

Functionality spirally increases as *Y* increases.

$$N(t) = Y(t)\left(\frac{1}{1 - \frac{1}{a} \cdot \frac{\Delta Y(t)}{Y(t)}}\right) \quad \Rightarrow \quad FD = \frac{N(t)}{Y(t)} = \frac{1}{1 - \frac{1}{a} \cdot \frac{\Delta Y(t)}{Y(t)}} \qquad \Delta Y(t) = \frac{dY(t)}{dt}$$

Generate self-propagating dynamism



Appendix 6 Model Construction

Trends in music input into the market as well as its assets in market *Y* are normally subject to a phenomena similar to that demonstrated by an epidemic function as depicted in equation (A1).

$$\frac{dY}{dt} = aY(1-\frac{Y}{N}) \qquad \text{(A1)}$$

where *N*: upper limit of diffusion (carrying capacity), and *a*: coefficient governing the velocity of diffusion.

This equation is developed to a logistic growth function as depicted in equation (A2)[10].

$$Y = \frac{N}{1+be^{-at}} \qquad \text{(A2)}$$

where *b*: coefficient identifying the initial state of diffusion.

While *Y* seeks to attain level *N*, its velocity would be subject to external circumstances such as a change in paradigm, customers' preferences and emergence of competitive businesses and innovation. Therefore, equation (A1) should be rewritten to (A3), depending on circumstances 1 and 2.

$$\frac{dY}{dt} = a_1 D_1 \cdot Y(1-\frac{Y}{N}) + a_2 D_2 \cdot Y(1-\frac{Y}{N}) \qquad \text{(A3)}$$

where D_1 and D_2: dummy variables demonstrating circumstances 1 and 2, respectively.

This is the same as the initial state of diffusion as represented by coefficient *b*.

Therefore, in case of two circumstances which make music industries react differently, each respective music industry follows the following hybrid logistic growth trajectory:

$$Y = \frac{N_X}{1+b_{X1}D_1e^{-a_{X1}D_1t}+b_{X2}D_2e^{-a_{X2}D_2t}} \qquad \text{(A4)}$$

where *X* classifies sectors of music industry as *P* (physical), *D* (digital) and *L* (live).

This hybrid logistic growth (*HLG*) model (Watanabe Naveed model) demonstrates a high level of fitness in relation to actual behaviors of music industries reacting to the circumstances' change.

[10] This simple logistic growth function (*SLG*) can be considered an approximation of a logistic growth function within dynamic carrying capacity (*LGDCC*) under the following conditions (see Appendix 3):
$\frac{\frac{b_k}{b}}{1-\frac{a_k}{a}}e^{(a-a_k)t} << 1$, $(a-a_k)t << 1$, $\frac{b_k}{b}\cdot\frac{1}{1-\frac{a_k}{a}} << 1$ $\frac{b_k}{b} \le \frac{b_k}{b}\cdot e^{(a-a_k)t} << 1-\frac{a_k}{a}$ therefore, $(a-a_k)t << 1$, $\frac{a_k}{a}+\frac{b_k}{b} << 1$

Appendix 7 *LGDCC* Logistic growth Regression Estimation

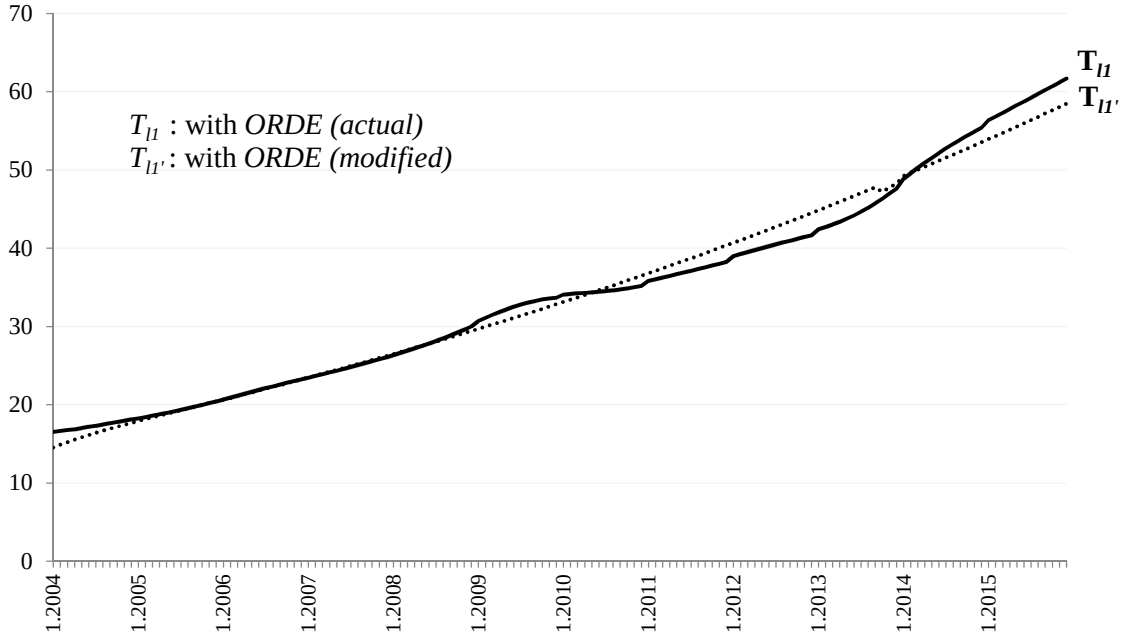


Fig .A3. *LGDCC* Logistic growth Regression Estimation

Calculation $\mathrm{T}_{l1} = (Y_{l1} + \mathrm{z} \cdot T_d)$

1. ***LGDCC*** $$Y_1 = \frac{N_k}{1 + be^{-at} + \frac{b_k}{1-\frac{a_k}{a}} e^{-a_k t}}$$

2. **Computation** $\overline{\mathrm{Y}_1}$ $(calculated\ by\ using\ the\ estimated\ coefficients)$

3. **Regression** $T_1 = a + \beta \overline{Y_1}$

4. **Computation** $\overline{\mathrm{T}_1}$ $(calculated\ by\ using\ the\ estimated\ coefficients)$

4´ (1) **Average** $\overline{T'} = \frac{\mathrm{T}+\overline{\mathrm{T}}}{2}$ $2004/1 - 2015/12$

4´ (2) **Average** $\overline{T''} = \frac{\mathrm{T}+\overline{\mathrm{T}}}{2}$ $2013/10 - 2013/12$

5. ***LGDCC*** $$\overline{\mathrm{T}} = \frac{N_k}{1 + be^{-at} + \frac{b_k}{1-\frac{a_k}{a}} e^{-a_k t}}$$

References

[1] Barreca, S.L., 1998. *Technology Life-Cycles and Technological Obsolescence.* BCRI Inc., Birmingham, Alabama.

[2] Bhhattacharjee, S., Gopal, R., Lertwachara, K., Marsden, J.R. and Telang, R., 2007. The Effect of Digital Sharing Technologies on Music Markets: A Survival Analysis of Albums on Ranking Charts. *Management Science*, 53 (9), 1359-1374.

[3] Bylin, K., 2009. Conditioned to Steal: Popular Music and Obsolescence in America. *Hypebot. Com*, August. Retrieved 25 December 2016. http://www.hypebot.com/hypebot/2009/08/conditioned-to-steal-popular-music-and-obsolescence-in-america.html.

[4] Choi, H. and Burnes, B., 2013. The Internet and Value Co-creation: The Case of the Popular Music Industry. *Prometheus*, 31 (1), 35-53.

[5] Cross, A., 2012. A Lesson on the Theory of the 13-year Music Cycle. *Journal of Musical Things*, March 25, 1-7.

[6] Diadato, V. and Smith, F., 1993. Obsolescence of Music Literature. *Journal of the American Society for Information Science*, 44 (2), 101-112.

[7] El Gamal, A., 2012. The Evolution of the Music Industry in the Post-Internet Era. *CMC Senior Thesis, Claremont College*, 532.

[8] Erika, P., 2016. Co-creating an Engaging Live-streamed Concert with Potential Viewers. *Master's Thesis, Degree Program in Service Innovation and Design, Laurea University of Applied Sciences.*

[9] Fly, B., 2016. How Does Music Consumption Impact the Music Industry and Benefit Artists? *Accounting Undergraduate Honors Thesis, University of Arkansas*, 20.

[10] Freeman, J., 2010. Web-based Collaboration, Live Musica Open-form Scores. *International Journal of Performance Arts and Digital Media*, 6 (2), 149-170.

[11] Gronow, P., 1983. The Record Industry: The Growth of a Mass Media. in Middleton, R. Edt., *Popular Music*, Vol. III., Cambridge University Press, Cambridge.

[12] Jennings, C., Wu, D. And Terpenny, J., 2016. Forecasting Obsolescence Risk and Product Life Cycle with Machine Learning. *IEEE Transactions on Components, Packaging, and Manufacturing Technology*, 6 (9), 1428-1439.

[13] Kirshbaum, J., 2016. Seven Top Music Marketing Trends for 2016. Hypebot, January,2016.http://www.hypebot.com/hypebot/2016/01//6-music-marketing-trends-in -2016-draft.html Retrieved 22 December 2016.

[14] N. Luhmann, Trust and Power, John Wiley, Chchester, 1979.

[15] Meade, N. And Islam, T., 2006. Modelling and Forecasting the Diffusion of Innovation: A 25-year Review. *International Journal of Forecasting*, 22, 519-545.

[16] Modis, T., 2007. Strngths and Weakeness of S-curves. *Technological Forecasting & Social Change*, 74, 866-872.

[17] Music Ally Data map (musically), 2015. Global Music Industry Data on Sales. http://www.musically.com Retrieved 30 Novemeber 2016.

[18] Parry, G., Bustinza, O.F. and Vendrell-Herrero, F., 2012. Servitisation and Value Co-production in the UK Music Industry: An Empirical Study of Consumer Attitudes. *International Journal of Production Economics*, 135 (1), 320-332.

[19] Peterson, R.A. and Berger, D.G., 1975. Cycles in Symbol Production: The Case of Popular Music. *American Sociological Review*, 40 (2), 158.173.

[20] Pollstar, 2015. Pollstar Year End 2015 Special Edition. http://www.pollstar.com Retrieved 15 December 2016.

[21] Record Industry Association of America (RIAA), 2016. RIAA Year-End Revenue and Shipment Reports. https://www.riaa.com/u-s-sales-database/ Retrieved 15 October 2016.

[22] Sax, C. and Steiner, P., 2013. Temporal Disaggregation of Time Series. *The R Journal*, 5 (2), 80-87.

[23] Stafford, S.D., 2010. Music in the Digital Age: The Emergence of Digital Music and Its Repercussions on the Music Industry. *The Elon Journal of Undergraduate Research in Communications*, 1 (2), 112-120.

[24] Tschmuck, P., 2010. The Recession in the Music Industry: A Cause Analysis. Music Business Research, March 2010. https://musicbusinessresearch.wordpress.com/2010/03/29/the-recession-in-the-music-industry-a-cause-analysis/ Retrieved 29 December 2016.

[25] Turner, J., 2015. Seven Trends Impacting Live Music Events. *Eventbrite*, June 2015.http://www.festivalinsights.com/2015/06/trends-impacting-live-music-events/ Retrieved 22 December 2016.

[26] Watanabe, C., Zhu, B., Griffy-Brown, C. and Asgari, B., 2001. Global Technology Spillover and Its Impact on Industry's R&D Strategies. *Technovation*, 21 (5), 281-291.

[27] Watanabe, C., Takayama, M., Nagamatsu, A., Tagami, T. and Griffy-Brown, C., 2002. Technology Spillover as a Complement for High-level R&D Intensity in the Pharmaceutical Industry. *Technovation,* 22 (4), 245-258.

[28] Watanabe, C., Kondo, R., Ouchi, N., Wei, H. and Griffy-Brown, C., 2004*a*. Institutional Elasticity as a Significant Driver of IT Functionality Development. *Technological Forecasting and Social Change,* 71 (7), 723-750.

[29] Watanabe, C., Matsumoto, K. and Hur. J.Y., 2004*b*. Technological Diversification and Assimilation of Spillover Technology: Canon's Scenario for Sustainable Growth. *Technological Forecasting and Social Change*, 71 (9), 941-959.

[30] Watanabe, C., Lei, S. and Ouchi, N., 2009. Fusing Indigenous Technology Development and Market Learning for Greater Functionality Development: An Empirical Analysis of the Growth Trajectory of Canon Printers. *Technovation*, 29 (2), 265-283.

[31] Watanabe, C., Naveed, K. and Zhao, W., 2015*a*. New Paradigm of ICT Productivity: Increasing Role of Un-captured GDP and Growing Anger of Consumers. *Technology in Society,* 41, 21-44.

[32] Watanabe, C., Naveed, K. and Neittaanmäki, P., 2015*b*. Dependency on Un-captured GDP as a Source of Resilience beyond Economic Value in Countries with Advanced ICT Infrastructure – Similarity and Disparities between Finland and Singapore. *Technology in Society*, 42, 104-122.

[33] Watanabe, C., Naveed, K., Neittaanmäki, P. and Tou, Y., 2016*a*. Operationalization of Un-captured GDP: The Innovation Stream under New Global Mega-trends. *Technology in Society*, 45, 58-77.

[34] Watanabe, C., Naveed, K. and Neittaanmäki, P., 2016*b*. Co-evolution of Three Mega-trends Natures Un-captured GDP: Uber's Ride-sharing Revolution. *Technology in Society*, 46, 164-185.

[35] Watanabe, C., Naveed, K. and Neittaanmäki, P., 2017*a*. Consolidated Challenge to Social Demand for Resilient Platforms: Lessons from Uber's Global Expansion. *Technology in Society,* 48, 33-53.

[36] Watanabe, C., Naveed, K. and Neittaanmäki, P., 2017*b*. Co-evolution between Trust in Teachers and Higher Education toward Digitally-rich Learning Environments. *Technology in Society,* in print.

Authors Curriculum Vitae

Kashif Naveed is currently doing his Ph.D. in Economics and Business Administration from the University of Jyväskylä, Finland and he has completed his Masters of Science degree in Economics and Business Administration from the same university. Previously he had Bachelors' of Science degree in Computer Science from the Hamdard University Karachi, Pakistan. *(kashif.naveed.dr@gmail.com)*

Chihiro Watanabe graduated from University of Tokyo, Japan and is currently Professor Emeritus of Tokyo Institute of Technology, Research Professor of University of Jyväskylä, Finland, and also a Research Scholar, International Institute for Applied Systems Analysis (IIASA). (watanabe.c.pqr@gmail.com)

Pekka Neittaanmäki graduated from the University of Jyväskylä in Mathematics and is currently Professor and a Dean of the Faculty of Information Technology, University of Jyväskylä, Finland. (pekka.neittaanmaki@jyu.fi)

TIS_2017_11_Highlight

Highlights

Blue print for the survival of the music industry was demonstrated.

Co-evolution between streaming and live music was elucidated.

Live music has incorporated self-propagating function by assimilating digital music assets.

Live-concert-streaming music industry (*LCSMI*) was recommended for music industry future.

LCSMI corresponds to the historical demand of consumers.