



The Invention of Compact Discs

EIS Main Project

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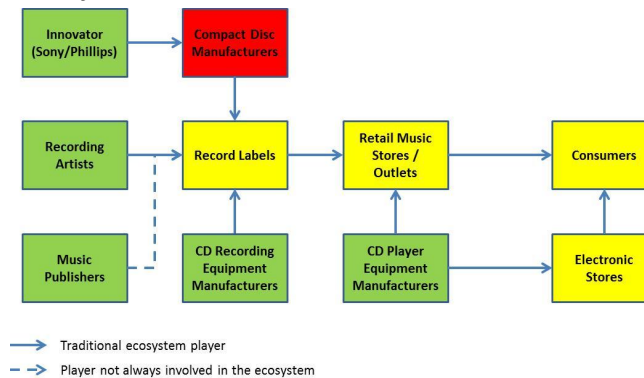
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EXECUTIVE SUMMARY

In 1982 Sony and Philips introduced the world’s first CD system – a 12-cm compact audio disc and a CD player – which quickly displaced the vinyl record and launched the music industry into a new world of high tech music production.

The music industry ecosystem the CD system entered into was centered on a few major Record Labels that dominated the industry. Although there were several other players in the ecosystem that needed to adopt CDs for them to be successful, the Record Labels were most important player to get on-board. While co-innovation was required for CD player development, the greatest co-innovation hurdle was the need for high-tech, capital-intensive CD production.

CD Ecosystem at time of Introduction:



Record Labels worried that consumers would not be willing to pay for the more expensive CDs, harbored piracy concerns and were hesitant to invest in a technology heavily dependent on unproven, capital-intensive production. In order to mitigate adoption chain and co-innovation risk, Sony and Philips created partnerships that aligned incentives for Record Labels and CD manufacturers to work together to promote the CD. Record Labels were also enticed by the value creation that higher-quality CDs offered through price premiums and consumers converting their back catalogs to CD format. While the invention of CDs was a massive technological disruption to the music industry, it reinforced the position of major Record Labels as the ecosystem power players. Retailers, artists, consumers, music publishers and producers all captured some value created by CDs, but ecosystem power did not shift.

The CD offered great potential for ecosystem carryover into video and data and CD innovators were careful to sequence the rollout of this technology. Sony and Philips established the minimum viable footprint for the CD in the music industry, before moving into new applications of the CD, some of which became very successful on their own (e.g., CD-R and CD-RW), others of which served as predecessor innovations to the ultimate standard that was adopted (e.g., CD Video prior to the DVD).

Today, CD sales are in rapid decline as web-based music and data storage solutions become increasingly popular. There does not appear to be a sustainable niche for CDs to retreat into, in either the music or data storage markets, as competitive formats are less expensive and more convenient. Thankfully, CD inventors Sony and Philips each have diversified product portfolios and R&D capabilities that will sustain them long after CDs disappear from the marketplace. Further, the knowledge created by Sony and Philips on how to manage innovation will endure in institutional memory, enabling success in future innovations and industries.

BACKGROUND

In 1979, after nearly ten years of working independently on technology, Sony and Philips joined forces to design a new audio format. The group, led by Kees Schouhamer Immink and Toshitada Doi, focused on advancing the laser and optical disc technology that each company had been developing. By 1980, Sony and Philips had created a compact disc with a 12-cm diameter and 16 bits of resolution.¹

The technology of the compact disc can be grouped into three key components: digital data processing, optics, and mechanics.² The basic mechanics of the CD is that a fine laser beam is focused onto the surface that contains digital information in the form of tiny pits. Due to the mirrored surface of the compact disc, the laser beam is reflected with the pattern of the pits to a photodiode. The signal is then detected and converted into analogue audio information. The compact disc is a non-contact readout system, which means that the CD essentially has an unlimited lifetime. Additionally, the CD has unmatched reproductive quality and, due to its high information density, a 12-cm compact disc can achieve playing times of up to an hour (later expanded to 74 minutes).³ Philips faced some challenges converting digital 'zeros' and 'ones' into analogue signals, but through its invention of 'Bitstream conversion,' a technology that uses 256 times oversampling and avoids digital distortion, they mastered analogue conversion.⁴ After succeeding in the technological feat of developing this new audio-data format, the real challenge for Sony and Philips began: commercialization.

CD technology was initially developed for application in the music industry, and as such, was considered by some as a huge threat to the vinyl LP record, the dominant recording and listening format of the time. After having made such a huge investment in LP records, the music industry was wary of a

¹ Philips Research, "The History of the CD – The Beginning", <<http://www.research.philips.com/technologies/projects/cd/index.html>>, 26 October 2012.

² Philips Research, "The History of the CD – Technology", <<http://www.research.philips.com/technologies/projects/cd/index.html>>, 26 October 2012.

³ IBID.

⁴ IBID.

new audio format when worldwide CD demonstrations began in 1982. With its joint venture with CBS consummated in 1968, Sony was the number one record company in the world. However, CBS had recently built a new plant to mass produce 30-cm LP records and was therefore hesitant to invest in a full scale CD software production plant.⁵ CBS executives wondered: why would we invest in a new audio format when the existing LP format continues to succeed? After much negotiation, Norio Ohga, Sony CEO and the father of the CD, convinced CBS that they needed only to invest a portion of CBS/Sony's huge annual dividend in order to build a CD manufacturing plant. CBS/Sony finally agreed to take a chance on this new technology and the first CD manufacturing plant was built in Shizuoka, Japan.⁶

In Tokyo on August 31, 1982 Sony, in conjunction with CBS/Sony, Philips, and Polygram, announced the launch of the world's first CD system.⁷ This new 12-cm CD was light, small, and nearly indestructible; along with the one-touch selection process used on the CD player, the CDP-101 also developed by Sony, this new system was a revolutionary experience for audio fans.⁸ Despite the enhanced functionality and superiority of the CD, and the fact that Sony and Philips had taken it upon themselves to invest in CD production capabilities and to invent and produce the CD playing systems (thereby eliminating hardware co-innovation risk), many adoption chain hurdles remained. For example, retailers were not happy about the double investment required to sell CDs and LPs, and they were skeptical of consumers' willingness to pay 20 euros per CD. Record Labels were skeptical of the CD's ability to outperform the LP on sound quality, and believed only that the CD could displace the less - important Compact Cassette, rather than the LP.⁹

⁵ Sony, "Sony History, Chapter 9: Opposed by Everyone,"
<<http://www.sony.net/SonyInfo/CorporateInfo/History/SonyHistory/2-09.html>>, 26 October 2012.

⁶ IBID.

⁷ Sony, "Sony History, Chapter 9: A Great Invention 100 Years On"
<<http://www.sony.net/SonyInfo/CorporateInfo/History/SonyHistory/2-09.html>>, 26 October 2012.

⁸ IBID.

⁹ Philips Research, "The History of the CD – The Introduction",
<<http://www.research.philips.com/technologies/projects/cd/index.html>>, 26 October 2012.

By 1983, just one year after the initial launch, several companies were selling CD players and approximately one thousand titles were available; however, the continued high price and yet to be appreciated value proposition meant a lackluster start for CDs. Sony realized that in order to move from early adopters to the mass market, something needed to change. It therefore decided to create the first portable CD player, the D-50. In November 1984, the D-50 was launched, and that was the key co-innovation that created meaningful demand for the CD.¹⁰ Again, Sony mitigated co-innovation risk by producing the needed innovation itself, investing in the CD's ecosystem to ensure its ultimate success. By 1985, roughly 25 million CDs and 5 million CD players had been sold. A year later those figures had doubled. The CD and CD player were the new audio sensation, and as the CD took off, the LP disappeared. LP sales declined at nearly the exact same rate as CD sales accelerated.¹¹ Just four years after its introduction, CDs were established as the principal audio medium in the music industry, with annual CD production reaching 100 million in 1988.¹² Audio cassettes and the gramophone also eventually disappeared. After overcoming several innovation challenges, CDs were the new audio standard dominating the audio world.

The CD had broader relevance though. This new audio format also set the stage for the development of other applications by Sony and Philips, enhancing value capture for the innovators and the ecosystem. By the 2000s however, the advent of MP3s for music and flash drives for data storage threatened the dominance of CDs across multiple applications and sales began to decline. The rise and fall of the compact disc is a story of adoption chain and co-innovation risk and sequencing success, as well as an illustration of the speed of technological adoption, succession and obsolescence.

¹⁰ Sony, "Sony History, Chapter 9: A Great Invention 100 Years On"
<<http://www.sony.net/SonyInfo/CorporateInfo/History/SonyHistory/2-09.html>>, 26 October 2012.

¹¹ Philips Research, "The History of the CD – The Introduction",
<<http://www.research.philips.com/technologies/projects/cd/index.html>>, 26 October 2012.

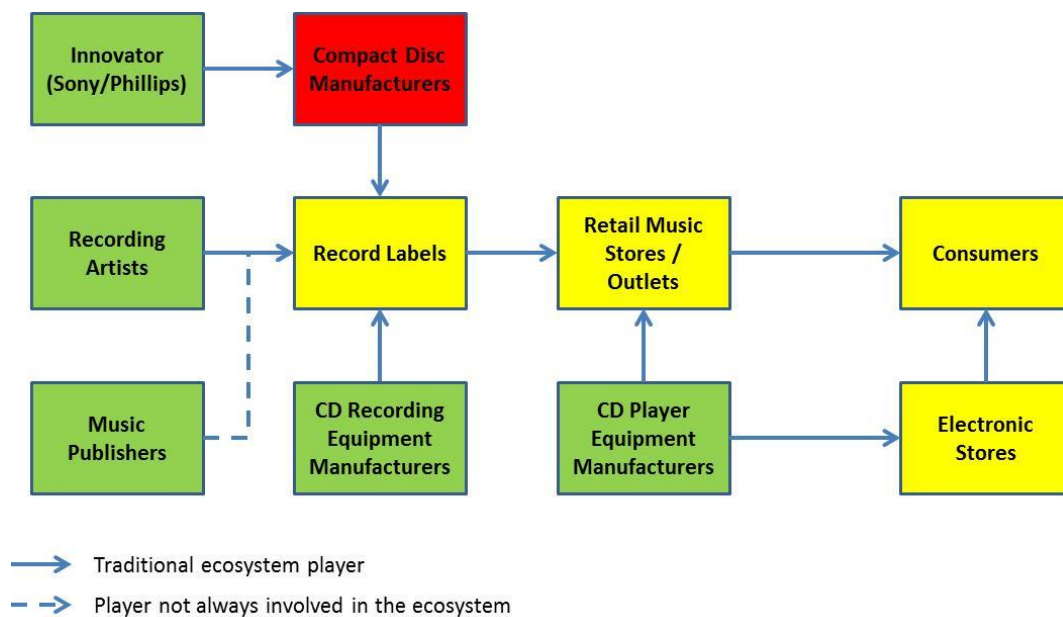
¹² Sony, "Sony History, Chapter 10: Studio Recorders Go Digital"
<<http://www.sony.net/SonyInfo/CorporateInfo/History/SonyHistory/2-09.html>>, 26 October 2012.

THE ECOSYSTEM THE CD ENTERED IN THE EARLY 1980s

The CD was first developed by Sony and Philips as a new standard for recording and distributing music to consumers; thus, the original players in the CD ecosystem were the same players that made up the music industry in the early 1980s. Sony and Philips needed to understand the music industry ecosystem in order to determine if these players would adopt and accept CDs as the new standard form of audio media. The questions they faced were:

- Who were the key players?
- With which players did the power and value capture lie?
- Which players needed incentives to adopt CDs and what solutions could be designed to redistribute surplus to turn a minus into a plus?

Exhibit 1: Compact Disc Ecosystem Map



VALUE CREATION OF COMPACT DISCS: CO-INNOVATION AND CO-ADOPTION

Innovator (Sony/Philips) – In June of 1980, Sony and Philips formally proposed a standard for the CD. Matsushita, another electronic equipment manufacturer, then adopted the CD standard in 1981, alongside the Digital Audio Disc Committee. The Philips/Sony engineering collaboration ended in 1981, and each company set about creating its own products. However, “they agreed that if either was unable to design a commercial product, the other would donate its design. The agreement was not needed. The compact disc was introduced in Europe and Japan, and then in the United States.”¹³ To ensure that other players in the ecosystem would adopt the new CD standard and co-innovate, Sony and Philips both licensed their technology liberally. By 1981, over 30 firms had signed the licensing agreements to use the technology, and other firms actually withdrew competing prototypes¹⁴ - green light.

Recording Artists – The recording artist is the foundation of the music industry. S/he is a musically gifted individual that composes and/or performs the music that is eventually sold to the consumer. Recording artists enter into a contract with a record label for their music to be commercially produced and marketed to a broad audience. Artists receive royalties for each album sold – ranging from nine to twenty five percent based on their track record and sales¹⁵. The CD offered better sound quality, a direct benefit to recording artists. The better their sound is, the greater amount of consumer appreciation for their music, which flows back to the artist in the form of greater popularity, leading to higher CD sales and performance attendance. In the process of innovating and commercializing the CD, Sony and Philips consulted musicians to determine the maximum recording time for the CD, thereby helping to mitigate the adoption chain risk that recording artists might find the CD unsuitable to their needs. “According to one version of history, the playing time was selected because conductor Herbert von Karajan demanded

¹³ The Compact Disc Handbook, 2nd Edition. Pohlmann, Ken C. 1992.

¹⁴ The Dynamics of Technological Adoption in Hardware/Software Systems: The Case of CompactDisc Players Author(s): Neil Gandal, Michael Kende and Rafael Rob. The RAND Journal of Economics, Vol. 31, No. 1 (Spring, 2000).

¹⁵ Adner, Ron, Annet Aris, and Peter Zemsky; “The Music Industry on the Brink of the Digital Age”; Insead; 2006.

a 74-minute capacity so his favorite piece, Beethoven's Ninth Symphony, would fit on a single disc. The other version claims the wife of Sony Chairman Akio Morita insisted that Beethoven's Ninth Symphony, her favorite piece, fit on one disc."¹⁶ Additionally, at the time of the invention of the CD, artists had no ability to impact the medium on which their music was distributed and were therefore at the mercy of the record labels; CD innovators thus faced little adoption risk or co-innovation risk with artists – green light.

Music Publishers – Music publishers managed the rights to songs that were not composed by the artists themselves, but which were instead created by composers and lyricists. Working with record labels, publishers identified which songs best fit which artist. In return, they received 6.9 cents per song as royalty¹⁷. Music publishers posed no co-innovation or adoption risk for CD innovators as they were not responsible for recording the music on to an audio format, but instead only responsible for linking music to artists for the record label – green light.

Compact Disc Manufacturers – Before invention of the CD, there were no compact disc manufacturers. The entirely new technology was not compatible with the manufacturing plants that produced vinyl records. However, the competing technology of the Mini Disc could be produced in the factories that produced vinyl records¹⁸ and was thus favored. For this reason, the CD faced adoption risk by existing audio equipment manufacturers as it was not a favored product. CD innovators also faced co-innovation risk from manufacturers, since significant infrastructure investments would be needed to build new factories to produce the new CD technology – red light.

Record Label or Music Groups – Record Labels, also known as Music Groups, were the largest and most powerful players in this ecosystem. They controlled the recording, publishing and distribution of music.

¹⁶ The Compact Disc Handbook, 2nd Edition. Pohlmann, Ken C. 1992.

¹⁷ Adner, Ron, Annet Aris, and Peter Zemsky; "The Music Industry on the Brink of the Digital Age"; Insead; 2006.

¹⁸ Philips Research, "The History of the CD – The Black Giants", <<http://www.research.philips.com/technologies/projects/cd/blackgiants.html>>, 26 October 2012.

The Record Label companies believed that the existing base of at least 300 million record players was a strong argument in favor of existing technology and worried about whether listeners would trade up to higher-priced CDs. For only a small investment, listeners could improve the sound of traditional records using CX (Compatible Expansion) and achieve the high quality sound of live music¹⁹. Record Labels also expressed concern for fraudulent copying with the new format. A big fear was that all the rights and royalties for music were lost if listeners could easily copy recordings onto a blank CD. Sony and Philips' published CD standards and playback preventions helped mitigate this. Another concern the Record Labels had was that CDs would require the Record Labels to invest in significant capital expenditures for new technologies, specifically recording devices. Only major Record Labels could afford to make such large investments, and this ultimately helped reinforce the entry barriers for smaller Record Labels, thereby strengthening the dominant position of the major Record Labels. This incentive combined with the potential revenue from music fans converting their existing collections from vinyl to CD helped to mitigate some of the adoption risk – yellow light.

Equipment Manufacturers – The equipment manufacturers can be broken down into two parts:

- *Recording equipment* – Recording equipment for digital recording was already in production by the introduction of the CD in 1982. One of the industry leaders was New England Digital Corp. in White River Junction, VT, which invented the Dartmouth Digital Synthesizer (later to become the Synclavier) in 1979.²⁰ With recording equipment manufacturers already producing digital equipment, there were no obstacles to CD equipment production – green light.

¹⁹ Philips Research, "The History of the CD – The Black Giants", <<http://www.research.philips.com/technologies/projects/cd/blackgiants.html>>, 26 October 2012.

²⁰ Vintage Synth Explorer, "New England Digital Synclavier", <<http://www.vintagesynth.com/misc/synclav.php>>, 26 October 2012.

- *CD Players* – CD player production was guaranteed by the involvement of leading electronic equipment manufacturer Sony in the CD initiative. The move by Sony to produce CD players, with the first being introduced in 1982, led other electronic equipment manufacturers to develop CD players as well, most notably Philips in 1983. In 1984, second generation CD players were introduced, along with automobile CD players.²¹ The convenience that these offered, and the fact that both the CD players and CDs were innovated and launched simultaneously, allowed for the mass adoption of the new technology – green light.

Retail Music Stores / Outlets – Retail music stores sell the recorded music produced by the record labels.

At the time of the invention of the CD, these outlets carried audiocassettes and records. Introducing the same music (same artists and songs) on a new medium would take up limited shelf space and force retailers to allocate valuable space to an unproven product. Additionally, some retailers were fearful that the small size of CDs would lead to increased theft²² and that CDs would be another short lived fad, like the eight-track cassette²³. However, retail music stores were ultimately at the mercy of the Record Labels – if the Record Labels chose to only produce music in the CD format, the retail stores would have to sell it. This dependency and uncertainty indicated that retail music stores would be forced to adopt the new product, but most likely with a degree of hesitation and delay; however, if consumers responded favorably to CDs and started converting their music collections, the retailers would stand to benefit from a significant new revenue stream and likely speed their adoption – yellow light.

Electronic Stores / Outlets – Similar to retail music stores that would be required to sell CDs, electronic stores such as the Wiz and Circuit City would be required to sell compact disc players. These outlets had limited floor space, for which a variety of products competed. Merchants understandably only buy

²¹ The Compact Disc Handbook, 2nd Edition. Pohlmann, Ken C. 1992.

²² Philips Research, “The History of the CD – The Introduction”,
<<http://www.research.philips.com/technologies/projects/cd/index.html>>, 26 October 2012.

²³ IBID.

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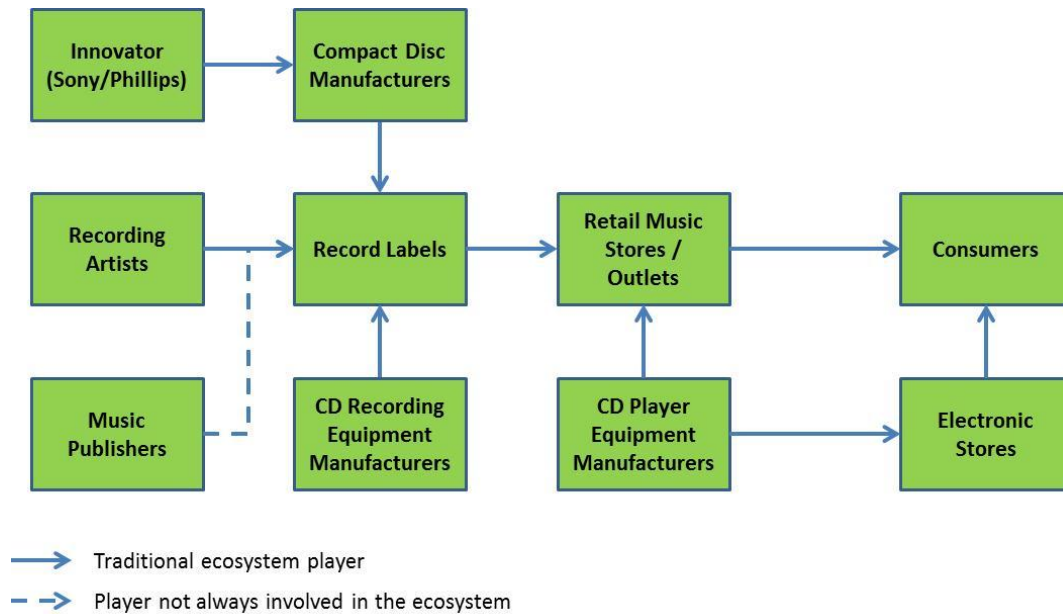
inventory in products they believe will sell. Thus, until CD innovators were able to prove that CDs would be demanded by consumers, they were likely to face adoption risk by electronic stores. However, if Record Labels moved all audio to CDs and chose not to record on vinyl and other existing mediums, retailers would be forced to stock CD players to meet demand for music players. The dependency of the electronic store / outlet on the Record Label meant that, similar to retail music stores, electronic retailers would be slow to adopt the new technology until demand was certain – yellow light.

Consumers – Consumers would initially be resistant to a change in the format. Consumers had already invested a substantial amount in both record players and record collections. With the introduction of the CD, consumers would be forced to buy a new music player and either have space to store both formats or buy all new CDs for the music they previously listened to on vinyl records. However, if CD technology was proven to be superior to existing formats (vinyl records, cassette tapes, etc.) music aficionados were likely to make the investment and purchase the new technology. The challenge rested in convincing the average music consumer to adopt the CD. However, if new music was only produced in the new CD format, consumers would have to convert to CDs to listen to the most current music – yellow light.

ALTERING THE ECOSYSTEM: OVERCOMING CO-INNOVATION AND ADOPTION CHAIN RISK

The success of CDs depended on adoption by all players in the ecosystem – all players on the value blueprint needed green lights. This required the inventors (Sony and Philips) to collaborate to reduce the co-innovation and /or adoption risk that other players faced and which made them yellow or red. The barriers were likely too large for one company to take on themselves, when each player in the music industry operated at such scale, and influential players needed to see a clear surplus from the CD. Together, Sony and Philips aligned the ecosystem for success.

Exhibit 2: Modified Compact Disc Ecosystem



Compact Disc Manufacturers – The innovators of the compact disc needed to find a manufacturing plant that could create the physical CD. To entice manufacturers to invest in the new production technology, both Sony and Philips partnered with players that had existing manufacturing facilities, thereby driving production themselves through strategic alliances. Although CBS Records was initially hesitant about adopting the CD, they were compelled to build the first CD manufacturing plant in Japan in partnership with Sony. Similarly, Philips partnered with one of its holding companies, Polygram, for manufacturing CDs²⁴. Subsequent entrants included Capital/EMI, another Record Label. Ultimately, the production of CD titles was done by a relatively small number of large record companies integrated into CD production.²⁵ By promoting manufacturer/Record Label partnerships, Sony and Philips created a more vested interest on the part of key ecosystem players, leading to scale production of the CD – green light.

²⁴ Wikipedia.Org, “PolyGram”, <<http://en.wikipedia.org/wiki/Polygram>>, 26 October 2012.

²⁵ The Dynamics of Technological Adoption in Hardware/Software Systems: The Case of CompactDisc PlayersAuthor(s): Neil Gandal, Michael Kende and Rafael Rob. The RAND Journal of Economics, Vol. 31, No. 1 (Spring, 2000).

Record Label or Music Groups – Record Labels were hesitant to adopt the CD, in part due to piracy concerns, but also due to the existing 300 million record players owned by the public. These devices could already play the billions of records in the market and Record Labels worried that consumers would resist converting to the new music medium. However, CD innovator Sony removed much of this hesitation when it formed its joint venture with CBS Records (later acquired)²⁶. Under the joint venture, CBS Records had an interest in publishing music on the CD format developed by its partner, Sony. Recording studio engineers also resisted conversion to digital technology, claiming that it was more expensive and that the sound was inferior. Sony overcame the challenge of Record Label adoption through the endorsement of famous artists such as Herbie Hancock and Stevie Wonder.²⁷ These endorsements by established musicians meant that competing new artists, from whom the Record Labels make the majority of their profits, would likely want to be recorded on the new format to achieve legitimacy in the highly competitive music industry that survives on star quality. Already, the greater sound and reliability offered by CDs would give Record Labels the ability to capture more value from the CD price premium, and the potential for incremental revenue from consumer conversion of back catalogues helped Sony to remove much of the adoption risk facing Record Labels. Record Labels also liked that CDs reinforced their dominant position in a hit-based industry, as listeners could now fast-forward and song select to their favorite songs and listen to their music on-the-go – green light.

Retail Music Stores / Outlets – Retail music stores were not keen on investing in both CD and LP formats simultaneously. Many retailers took the “wait and see” approach, reluctantly stocking a small selection of CDs, planning to scale up or down based on consumer demand. Demand quickly exploded over two

²⁶ Wikipedia.Org, “Sony Music Entertainment”, <http://en.wikipedia.org/wiki/Sony_Music>, 29 October 2012.

²⁷ Sony, “Sony Corporate Info – Sony History”, <<http://www.sony.net/SonyInfo/CorporateInfo/History/SonyHistory/2-10.html>>, 29 October 2012.

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years, to the point where manufacturers were struggling to keep up²⁸. Retail music stores saw consumers quickly shifting to purchase the more portable CD audio option and began allocating more shelf space to CDs, at the expense of space for LPs. Adoption risk was thus overcome – green light.

Electronic Stores/ Outlets – Similarly, electronic stores saw a greater value proposition in satisfying growing consumer demand for CD players. Sony's partnerships with CBS Records helped bring together the manufacturing and recording worlds. Through this partnership, new music of top artists (e.g., Michael Jackson²⁹) was recorded on CDs and thus helped bring popularity to the new medium. As consumer demand increased for CDs, any previous adoption risk for CD players faced by electronic stores was overcome – green light.

Consumers – In order to entice consumers to forego their existing music players and records, CD innovators had to convince consumers that CDs offered superior benefits compared to records or audio cassettes. Sony extended its Walkman brand to include a portable player for the compact disc in 1984, the Discman (D-50). The invention of the Discman provided greater sound quality than the Walkman and allowed music to be listened to on-the-go, a benefit not offered by vinyl. Thus, Sony's release of the D-50³⁰ quickly sparked interest in CDs and helped significantly lower the price of competing CD players, thereby reducing adoption risk for consumers. Also, as soon as listeners bought a CD player, they were locked-in to the format, driving future CD sales as new artists emerged – green light.

MINIMUM VIABLE FOOTPRINT and SEQUENCING SUCCESS

The Audio CD was the minimum viable footprint with which Sony and Philips launched the new CD technology. With Sony's leadership in the audio equipment manufacturing industry and its

²⁸ Philips Research, "The History of the CD – The Introduction", <<http://www.research.philips.com/technologies/projects/cd/index.html>>, 28 October 2012.

²⁹ Wikipedia.Org, "Sony Music Entertainment", <http://en.wikipedia.org/wiki/Sony_Music>, 28 October 2012.

³⁰ Wikipedia.Org, "DiscMan", <<http://en.wikipedia.org/wiki/Discman>>, 28 October 2012.

relationship with one of the top Record Labels (CBS), Sony and Philips overcame competition from other formats (CX, Mini Disc) and investment hurdles for CD manufacturers, Record Labels and consumers, to successfully launch the CD. As discussed, CDs offered better sound quality, a smaller, more durable and longer-lasting physical form, and a new worldwide standard for audio content formatting in a digital era, a clear value proposition to players throughout the ecosystem, once adoption costs were surmounted. This value proposition secured Sony and Philips' leadership in driving ecosystem success, and enabled smart followership across other ecosystem players as Sony and Philips moved in a supportive, non-threatening way.

The technology and ecosystem tactics, however, did not only apply to audio content. At the onset, the CD showed high potential for applications in video and data, and elements including text, graphics and animation were added over time. The key for Sony and Philips, the ecosystem innovators, was sequencing success through these ecosystems. Having achieved a minimum viable footprint and legitimacy in the music industry, Sony and Philips were better prepared to set the worldwide standard for technologies in video (DVDs) and data (CD-ROMs) that leveraged the system put in place for audio. The Audio CD commercialized in 1982-1983 is ancestor to an optical disc family with a wide range of applications, some of which became very successful on their own, others of which served as predecessor innovations to the ultimate standard that was adopted. By sequencing the development of additional elements for the Audio CD, and leveraging elements developed in the construction of the music industry ecosystem to enable the construction of a second and third ecosystem, Philips and Sony strategically led the expansion of CD technology into ecosystems for computing and video. The following list describes the applications that Sony and Philips enabled by adding elements to its minimum viable footprint:

- *CD Single*: An 8-cm CD with a maximum playing time of 20 minutes and the same sound quality as the standard 12-cm CD targeted the music singles market. This application was able to be

played on a standard CD player. CD singles are also increasingly used in CD-R form to store MP3 music files at low cost.³¹

- *CD Graphics*: CD graphics enabled song lyrics and other information contained on a CD to be displayed on a TV while the CD was being played. This was an early feature of CDs that was never successful.³²
- *CD-ROM*: Launched in 1985, only two years after the CD commercial introduction, the CD-ROM stores computer software and data. The CD-ROM set the worldwide standard for fast, highly-reliable data access. The CD-ROM has the same 12-cm diameter as the audio CD and storage capacity of 650-700 MB, 450 times more than floppy disks.³³
- *CD Video*: Developed in 1987 by Sony and Philips, the joint license holders for optical discs, in 12-, 20- and 30-cm disc sizes, CDVs held up to 5 minutes of analog video and up to 20 minutes of digital audio. They were intended to carry video clips. The larger disks could hold more content, but were not playable in standard CD players.³⁴ By 2000, CDVs were displaced by DVDs, invented and developed by Philips, Sony, Toshiba and Panasonic in 1995. Competing formats for digital video at the time of development included the Multimedia Compact Disk (MMCD) developed by Philips and Sony, and the Super Density (SD) disc backed by Toshiba, Time Warner, Matsushita Electric, Pioneer, Thomson and JVC.³⁵ While DVD technology was a different digital encoding format from the CD, Sony and Philips led the convergence to a single standard disc format for video, carrying over technological expertise and industry leadership from the music industry to the film industry. Importantly, Sony and Philips formed alliances with other developers to

³¹ Philips Research. "The History of the CD – The CD Family"

<<http://www.research.philips.com/technologies/projects/cd/cd-family.html>>. 2 November 2012.

³² IBID.

³³ IBID.

³⁴ IBID.

³⁵ Wikipedia.Org, "DVD", <<http://en.wikipedia.org/wiki/DVD>>, 2 November 2012.

advance the technology while avoiding a format war, resulting in a single format that combined technologies from the SD and MMCD camps.

- *CD-i*: In 1991, the CD-i, which combined CD audio with video, text, animation and interactivity, was launched. In partnership with Full Motion Video and with over 50 titles at introduction, Philips envisioned success in learning and gaming. CD-i could display more than 16 million colors and could hold up to 7,000 photos, 72 minutes of animation or 19 hours of audio, or any combination of the three. Philips had made great strides in developing the ecosystem for such a product, involving over 850 companies, including product developers, studios, publishers, player manufacturers, TV producers and ad agencies. However, the product failed with the success of PCs and gaming consoles.³⁶
- *Video CD*: The same size as the audio CD with capacity of 74 minutes of audio and video, the video CD was launched in 1994 as a further development of CD Video and CD-i to complement the audio CD for recording live concerts and offered a new AV medium for feature films, karaoke, language courses and animated children's books, among other applications. The Video CD was quickly overtaken by the superior DVD in most intended applications; however, it remains a part of karaoke applications in the Far East.³⁷
- *CD-R and CD-RW*: In 1991, CD-R (CD-Recordable) was first introduced for professional use. CD-RW (CD-ReWritable) came to market in 1997, and was soon combined with CD-R and sold blank to support read-only and re-writable media.^{38,39}

Staging the expansion of CD storage capabilities into text, graphics, animation and interactivity increased the value creation potential for Sony and Philips in both the music industry ecosystem and in

³⁶ Philips Research. "The History of the CD – The CD Family"
<<http://www.research.philips.com/technologies/projects/cd/cd-family.html>>. 2 November 2012.

³⁷ IBID.

³⁸ IBID.

³⁹ Wikipedia.Org, "CD-ROM", <<http://en.wikipedia.org/wiki/CDROM>>, 2 November 2012.

new ecosystems, specifically video and computing ecosystems. In each CD application Sony and Philips developed, they added elements to the minimum viable footprint of the Audio CD “so that each new element benefits from the system already in place and increases value creation potential for the subsequent element to be added”⁴⁰.

As Sony and Philips pursued a staged expansion strategy of adding new elements to the Audio CD, they needed to create and secure universally accepted standards on format. Carrying CD technology over into video and computing ecosystems would require them to replicate their success in setting standards for the Audio CD, as they had with the publication of the “Red Book” that defined the technical specifications of the format. The adoption of the “Red Book” across the music industry locked in complements (CD players) and customers to the particular format developed by Sony and Philips, and created a single platform with which other industry players—artists, music publishers, record labels—could align. Although the exact technology of the Audio CD didn’t always prevail, Sony and Philips drove the development of standards in both video and computing disc formats. In 1985, Philips and Sony established the “Yellow Book” CD-ROM standard, defining the medium for computer data storage as the same physical format as audio CDs and readable with a CD-ROM disk drive on a computer. In 1995, Sony and Philips worked with other industry players to define the ISO standards for DVDs. Sony and Philips’ proactive development of standards in CD-ROMs and DVDs enabled them to construct second and third ecosystems similar to the ecosystem created in the music industry, increasing the value creation of the initial innovation.

BOLD RETREAT

October 1st, 2012 marked the 30th anniversary of the compact disc, the release of Billy Joel’s 52nd *Street* in Japan. For decades, the compact disc dominated global record sales as the primary format for

⁴⁰ Ron Adner. *The Wide Lens: A New Strategy for Innovation*. Portfolio Penguin. 2012.

recorded sound. Last year, 300 million CDs were sold; however, the sales of physical albums were surpassed by sales of digital tracks.⁴¹

CDs are well on their way towards becoming an obsolete technology, replaced by internet downloading and streaming, USB and cloud computing technology. Consumers are accessing music, video and data content on their PCs, laptops, smartphones and tablets. Innovations in hardware and software for the computer industry have created new modes of accessing content, eliminating consumers' need for physical audio, video and data storage as well as complementary products, the CD player, the DVD player and the disk-drive for computers. Further, the music industry is facing a severe and irreversible decline in consumer willingness to pay for music. \$18 dollar CD albums are far less competitive when listeners can buy their favorite songs on iTunes for 99 cents and download entire albums for \$9.99. Individual song purchasing by way of downloading has also eroded the value that Record Labels can extract from album sales, changing the game for them. Record Labels no longer derive power from the role they play as the album compiler and distributor. Under the new system, online music retailers and hardware designers have grown in power.

When physical storage is demanded, smaller, more durable, higher capacity flash drives offer better performance. In general, a new ecosystem for music, video and data delivery has emerged, removing players from the original ecosystems Sony and Philips created, bringing the creators of content closer to the consumers of content and changing value creation and value capture by players across the ecosystem value blueprint.

“The superior technology almost always wins in the end. Managers of old-technology firms who try to delay the inevitable often waste resources and damage their companies.”⁴² The best option to extend the value of CDs – no longer the superior technology – in the face of imminent decline is to

⁴¹ Joel Rose. “The CD, at 30, is Feeling its Age”. NPR Music. October 12th, 2012.

⁴² Ron Adner and Daniel C. Snow. “Bold Retreat: A New Strategy for Old Technologies”. *Harvard Business Review*. March 2010.

retreat to a sustainable niche where they have an advantage. The trouble for CDs is that there do not seem to be any sustainable niche markets for CDs. Although CD music albums still sell reasonably well in many markets (including for karaoke enthusiasts in the Far East), CD-ROMs are still used for software, and audio books, DVDs and BluRay remain popular formats for content, other formats will inevitably win out. The Internet offers greater convenience and reduces the hardware requirements for consumers with a wide range of digital content, while flash drives are the superior physical alternative, as they are ultra low-cost with high storage capabilities and are already established in schools and businesses for physical content transfer and storage of larger files. For music purists, vinyl records are preferable for their nostalgia and collector's item status. However, it is unlikely that CDs would ever achieve this sort of collector's item status, particularly at scale, and CDs would first have to be entirely phased out to create scarcity value. Without a niche market to retreat into, the CD ecosystem players will transition to the new web and cloud-based digital content ecosystems, and the CD will eventually become obsolete.

The compact disc exists today thanks to Sony and Philips' collaboration with one another as well as their identification and mitigation of co-innovation and co-adoption risk among ecosystem players. The continued success of the CD was a result of unique sequencing of added technological benefits that made CDs valuable to in a variety of industries, creating additional value for the CD inventors, Sony and Philips. "Omit any of these breakthroughs, and the CD as we know it today would have been a technological impossibility."⁴³

⁴³ The Compact Disc Handbook, 2nd Edition. Pohlmann, Ken C. 1992.

APPENDIX

CD Innovation and Adoption Timeline

1979: Philips launched compact disc.

1980: CD-DA format introduced by Philips and Sony, and standards were laid down in the Red Book.

1981: First test CD created in Hannover, Germany by the Polydor Pressing Operations plant.

1982: Manufacturing of CDs began on a large scale in a factory.

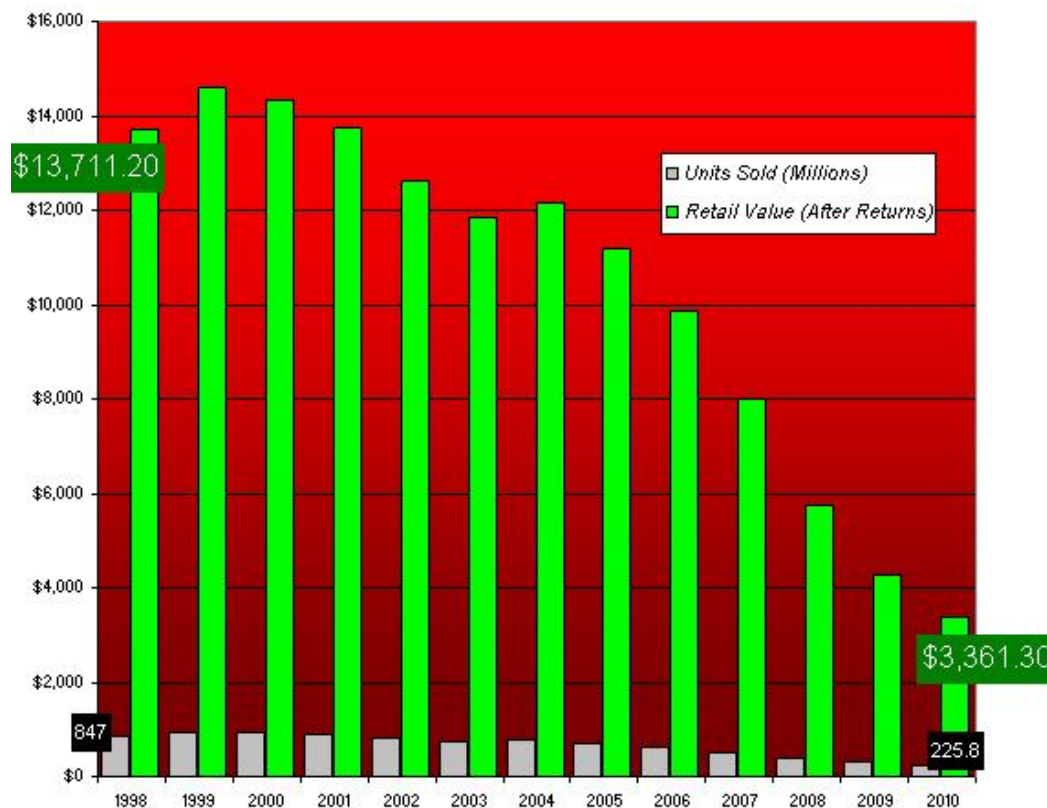
1982: First ever album on a CD released by Sony, which was Billy Joel's 52nd Street.

1983: CD players and discs hit the market in the US and the rest of the world.

1984: Advanced technology to store and retrieve data from CD-ROM introduced.

1985: CD-ROM drives introduced in the US and world markets. Dire Straits became the first artist to sell a million copies on CD.

Decline in CD Sales⁴⁴



⁴⁴ "The CD Slide: It's Way Worse than You Think". *Digital Music News*. June 2, 2011.