博士論文

Video Game Business Management Economics: Employing Industry-Level Data to Improve the Decision-Making Process

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Abstract

Current research into video game business management is sparse. What research does exist focuses on the creative process of video game development; however the business side can longer be neglected, with individual game development project budgets in excess of US $100 million in some cases. Business management decisions are made by publishers and developers based on their tacit knowledge of what has worked in the past according to their experience; however, left unverified there is a risk that this tacit knowledge may not reflect rapidly changing market realities. Managerial economics is concerned with the optimization of the decision-making process given limited resources, and such a rational decision-making process is required if publishers and developers want to ensure that the knowledge their organizations contain best reflects the reality of the wider industry. Through this research, I will rely on a managerial economics perspective and use knowledge discovery in database (KDD) techniques to answer the following questions:

- MRQ: How can an economic perspective that views decision optimization in terms of making the best use of limited organizational resources allow for the use of data from the wider industry to question assumptions and improve video game business management decision processes?
- SRQ1: What is the state of intellectual property exploitation and exploration strategies in innovation and business management practices within leading video game organizations and how are those strategies changing?
- SRQ2: What role do women play in making creative decisions within video game development organizations and how does this compare to video game consumer demographics?
- SRQ3: How do the product scope decisions made in video game project management reflect what provides value to consumers?

This research will propose a learning process tailored to a creative industry such as video game development as an answer to the major research question. Although tacit assumptions regarding how to best employ organizational resources are traditionally difficult to question because of the artistic or symbolic nature of the products of creative industries, a managerial economics perspective allows these assumptions to be questioned and tested in a rational manner. The proposed process incorporates data from the wider video game industry to falsify or validate assumptions behind management decisions. This approach will be applied in answering the three subsidiary research questions through quantitative research into the results of one strategic innovation management decision, one human resource or "talent management" decision, and two project management product scope decisions in the video game industry. The answers to these three research questions provide examples for how KDD techniques can contribute to improving decision-making within a creative industry such as video game development. The proposed learning cycle expands on the traditional "double-loop" learning cycle by incorporating two important steps: locating decisions based on tacit assumptions and framing questions to attempt to falsify those assumptions, and then employing KDD techniques with data from the wider video game industry falsify or validate the tacit assumptions behind those decisions.

Keywords: video game development, cultural and creative industry management, business management, managerial economics, knowledge discovery in databases

Preface

I hereby submit this dissertation in partial fulfillment of the requirements for the degree of Doctor of Philosophy in Knowledge Science in the School of Knowledge Science at Japan Advanced Institute of Science and Technology (JAIST). The research described in this dissertation was conducted under the supervision of Professor Kazunori Miyata of the School of Knowledge Science at JAIST. Except where specific reference is made to the work of others, the contents of this dissertation are my own original work and have not been previously submitted for any other degree. In cases where the papers referenced as chapter material include collaborators, I was the primary researcher, responsible for concept formation, data collection, analysis, and manuscript edits, and corresponding author for publication or presenter in the case of oral or poster presentations. A version of Chapter 5 is currently submitted for publishing consideration in an academic journal as Bailey, M., Miyata, K. (in review). Exploration and exploitation in video game development: An analysis of the shift in innovation trends in third-party console game publishers. A version of Chapter 6 has been published as Bailey, E., Miyata, K., and Yoshida, T. 2019. Gender composition of teams and studios in video game development. *Games and Culture*, doi: 10.1177/1555412019868381. A version of Chapter 7 has been published as Bailey, E., and Miyata, K. 2019. Improving video game project scope decisions with data: An analysis of achievements and game completion rates. *Entertainment Computing* Vol. 31, p. 100299, doi: 10.1016/j.entcom.2019.100299 and is based on an earlier poster presentation given at the 2017 International Conference on Entertainment Computing (ICEC). A version of Chapter 8 was published as Bailey, E.N. and Miyata, K., 2018. Estimating the Value of Multiplayer Modes in Video Games: An Analysis of Sales, Ratings, and Utilization Rates. *2018 IC3K/KDIR Proceedings* (pp. 153-160). In the chapters based on papers, the use of pronouns “we” or “our” refers to myself and the above co-authors involved in the research.

Eric Nelson Bailey, June 2020

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I extend my deepest respect and gratitude to Professor Kazunori Miyata, who supervised my research and provided me with the guidance I needed to proceed. Any time I had a question, it was soon answered, and the balance of freedom and instruction he lent helped me to grow as a researcher while managing family and work responsibilities.

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Last, and certainly not least, I would like to thank my wife Nahoko, my sons Kian and Aidan, my daughter Sheena, and my parents Katherine, Kent, and Marge for their encouragement and endless patience as I pursued this research. Balancing research, work, and family would have been impossible without their support.

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Fundamental Statistics

N = population size (the total size of a population of values)

n = sample size (the size of a sample within a population of values)

M = mean (the average of all values in a set of values)

Mdn = median (the value splitting a set of values into a higher and lower half)

SD = standard deviation (the amount of variation in a set of values)

95% CI = 95% confidence interval (95% likelihood that the true mean for a set of values lies in this range)

IQR = interquartile range (the range where 75% of a set of values lie)

Correlations

r_s = Spearman's rho (non-parametric measure of rank correlation, calculation based on deviations)

r_τ = Kendall's tau (non-parametric measure of rank correlation, calculation based on concordant and discordant pairs)

p = p-value (the probability that the null-hypothesis is correct, used in evaluating the significance of the results)

D = D-statistic (the Kolmogorov-Smirnov test statistic used to determine whether two distributions are different)

Regression Analysis

R^2 = R-squared, or the coefficient of determination (goodness of fit, the amount of variance in a dependent variable that can be predicted from the independent variable)

F = F-value or F-statistic (value used in determining the significance of a regression model)

List of Abbreviations

API = application programming interface

BI = business intelligence

CEDEC = Computer Entertainment Developers Conference

D.I.C.E. = Design Innovate Communicate Entertain (Summit)

DLC = downloadable content

DM = data mining

DSS = decision support systems

F2P = free-to-play

GDC = Game Developers Conference

HTML = HyperText Markup Language

IGDA = International Game Developers Association

IP = intellectual property

KDD = knowledge discovery in databases

RPG = role-playing game

SECI = Socialization, Externalization, Combination, Internalization (Spiral)

XML = Extensible Markup Language

Terminology

AAA — A term used to describe high-budget, "hit" video game titles, typically produced by a large publisher or developer. Typically used in contrast to "indie" games, which are developed by a smaller publisher or developer. In some cases, a distinction is made between "AAA" and mid-tier "AA" or "A" games.

Achievement — An event triggered by a video game and stored on a server, usually associated with the player's platform-specific user profile.

Boundaryless Career — Careers that are not contained within a single organization or industry. Typically, the boundaryless career holder advances their career through their work portfolio, rather than within an organizational structure.

Business Intelligence — Business intelligence systems are decision support systems that rely on data to operate and provide their users with information to assist in rational decision making.

Casual Gamer — In contrast to a "hardcore gamer", a casual gamer is a player of video games that prefers less complex, more intuitive interactions. Although the term is sometimes used to indicate a player who does not devote much time to video games, this is incorrect, as there are many casual gamers who spend large amounts of time and money playing games.

Completion — The act of finishing a single-player game's primary content. This does not include all of the content in the game, rather, it focuses on the "main path" content. In scenario-rich games, this is often the content that is required to finish the "story." In movies, it would be the equivalent of seeing the movie through to the end credits. In books, it would be the equivalent of reading to the end of the book.

Console — In video games, a "console" refers to a dedicated video game hardware platform, such as *Microsoft*'s *Xbox* or *Sony*'s *PlayStation* series of hardware platforms. This is in contrast to hardware platforms that

support video games as well as other software, such as *Apple*'s *Macintosh* or a PC.

Consumer — The person consuming video game or other creative content, distinguished from the customer who buys it, although they are often the same person.

Creative Industry — Although often used synonymously with "cultural industry", creative industries encompass a wider range of industries as it includes industries that produce products having value in use. In some cases, the term is expanded to include any industry relying primarily on knowledge work. It includes the video game industry.

Critic — A professionally hired reviewer of games who often provides a "score" as a final rating of quality based on the critical aspects of the game and how strongly they would recommend it to their audience.

Cultural Industry — Although often used synonymously with "creative industry", cultural industries are a subset of creative industries that produce copyrightable products with symbolic value. It includes the video game industry.

Customer — The person purchasing video game content, even if they are not the final consumer – as in the case of a parent buying the game for a child to play.

Data mining (DM) — A field or a method for knowledge discovery in databases (KDD) that relies on several fields, such as computer science, statistics, and database management. The goal is to identify patterns in data sets that could lead to knowledge discovery.

Decision Support — A method for assisting in management decisions based on predefined rules or patterns as a result of analysis of prior data.

Developer — A person or entity that creates video game software. In some cases, the developer is also the publisher of the game.

Director — The person in charge of a video game project's "creative vision" and typically the one who decides how the game will satisfy player needs. In some companies, the "lead game designer" is the equivalent of the director, while in others, there is a distinction between the "creative director" who holds the overall vision for the product and the "game director" who holds the responsibility for gameplay aspects.

Downloadable Content (DLC) — Content that expands the play options in a video game package – often requiring extra payment. A strategic response to the downward price pressure on primary video game content is to release several DLC packages for a game that the player may purchase, effectively raising the total price they pay for a game.

Exploitation — In contrast to "exploration", this strategy relies on leveraging existing competencies or intellectual properties to develop further products or services. As it relies on existing knowledge and organizational competencies, the likelihood of success is typically less "risky" in the short term.

Exploration — In contrast to "exploitation", this strategy relies on developing new products or services that do not rely on existing competencies or intellectual properties. As it relies on developing new knowledge, the likelihood of success is typically more "risky" in the short term.

Falsification — Falsification is a method used in science to avoid the problem of induction. Rather than stating an assumption or hypothesis and attempting to confirm its validity, the hypothesis is stated in a manner that seeks to disconfirm or "falsify" its validity. In this manner, a hypothesis can never be "proven", but a mistaken hypothesis can be revised or discarded in light of contradictory information.

First-Party — In contrast to "third-party", a video game software publisher who is also a hardware platform holder. Examples include *Microsoft*, *Nintendo*, and *Sony*. Their primary goal is to develop software to promote their hardware platform. In addition to developing their own

content, they typically extract fees from third-party developers in exchange for allowing them to publish games on the platforms they hold.

Free-to-Play (F2P) A business model for a video game that gives the basic software package away to consumers for free, often with the hopes of making money through advertising or the purchase of optional content.

Game Analytics A field devoted to analyzing the data produced by or through the sales and production of video games, including player behavior and marketing.

Game Designer A position unique to game development. Game designer responsibilities can vary, but usually involve deciding game content, constructing systems of play, planning and scheduling, drafting specifications, implementation, and tuning the interactive experience.

Gameplay A term that encompasses the unique "video game aspects" of a product, including how it controls or how it reacts to players.

Genre The classification of the video game into categories based on similar games. Genres include categories such as "Action" for games that require reflex responses, or "Roleplaying Games" for games that are more focused on growing a character or group of characters over the course of a story.

Hardcore Gamer In contrast to "casual gamer", a player of video games who seeks challenging or complex interactive experiences. Although the term is sometimes used to denote players who frequently play video games, "casual gamers" may also be frequent players of video games.

Independent Developer A video game developer not owned by a publisher. An independent developer may rely on a publisher, but sometimes handle the publishing or distribution aspects of their own game. With the increasing power of tools, there has been a subsequent rise in the number of independent or "indie" developers.

Indie Game — A game produced by an independent developer. Although the production values can be high, indie game projects typically do not possess the budget or resources of a "AAA" game project.

Knowledge Discovery in Databases (KDD) — A field or method that deals with trying to extract useful knowledge or information from databases.

Metacritic Rating — A score from 0 – 100 calculated by the web site *Metacritic* as an indicator of the quality of a game determined through an unreleased algorithm combining multiple critics and web site reviews. *Metacritic* ratings are also calculated and made available for other entertainment products, such as movies or music.

Mobile Game — A game distributed over a mobile device, such as smart phones or other mobile phones. The availability of free-to-play games, prevalence of casual gamers, and price sensitivity make the mobile game business model significantly different from console or PC games.

Multiplayer — A way of playing the game that requires multiple people to play, whether in cooperation or competition, as opposed to "single-player," which only requires one person to play.

Piracy — The illegal redistribution of copyrighted software, such as video game software.

Platform — Either the hardware or software platform used to run video games. Hardware platforms include the *PlayStation 4* and *Xbox One*, while software platforms include *Valve Corporation*'s *Steam* service, *Apple*'s *App Store*, and *Google*'s *Play Store*.

Player — The individual playing a game, distinguished from "user" which is used for more utilitarian software.

PlayStation Network (PSN) — *Sony*'s online platform for its *PlayStation* line of products, including the *PlayStation 3*, *PlayStation Vita*, and *PlayStation 4*.

Playtime — The amount of time a player has invested in the game. Most methods for measuring this are somewhat inaccurate, as time when the player has opened the video game software but is not actively using it is included.

Post-Mortem — A project management process where the decisions made through the course of a project are evaluated against results to discover what went well or poorly in the hopes of passing that knowledge to future projects.

Progression — The player's progress through the main path of a video game. This leads up to the "completion" of the game.

Producer — The person in charge of the management aspects of a video game project, including budgeting or marketing. The specific responsibilities of the role vary by company.

Project Owner — The person responsible for developing a project. In video game development companies, this is typically the "director," the "producer," or a combination of both.

Publisher — A business entity that sells video game software to retailers and consumers. In some cases, this corporate entity also contains developers; deal exclusively with publishing third-party developed content; or a combination of both.

Release Date — The first day video game software is made available for sale to the public.

Single-Player — A way of playing the game that only requires one person, as opposed to "multiplayer," which requires several people to play.

Steam	*Valve Corporation*'s digital storefront for PC video games and other software. It is currently the most popular platform for PC game distribution.
Studio	Borrowing from other art and entertainment industries, many video game development organizations use the term "studio" to refer to their business.
Studio Head	The manager of a video game development "studio," who might be equivalent to a development manager inside other software development companies. The studio head is often the gatekeeper who makes the decisions about whether to greenlight, or approve, new or ongoing game concepts.
Third-Party	In contrast to "first-party", a developer or publisher of video game software that does not own a hardware platform. Examples include *Activision Blizzard*, *Electronic Arts*, and *Square Enix*.
Trophy	*PlayStation Network*'s achievement implementation is in the form of "trophies" that players can earn.
User	Used to indicate the person utilizing software. In a video game context, this research prefers to refer to the users of game software as "players" except in the case of "user ratings" where the player has finished playing the game and is reviewing the game after the fact as they are no longer playing it.
Xbox Live	*Microsoft*'s online platform for its *Xbox* line of products, including the *Xbox 360* and *Xbox One*.

1. Purpose and Significance of the Study

Video game development organizations, like organizations in other cultural and creative industries, are experiencing rapid economic environmental changes that outdate their business knowledge, which is difficult to correct given nebulous definitions of what constitutes value in the products and services they produce. These organizations need to better question their business management assumptions and test whether they are valid in the markets they operate. They can do this by locating their assumptions and incorporating data from outside their firms into their decision-making processes and must do so in order to become learning organizations that will survive in an increasingly competitive environment.

This research applies a knowledge discovery in database (KDD) approach to areas in decision-making where tacit management assumptions can be verified against market realities. The approach focuses on the business value of tacitly held knowledge, which allows for the employment of a managerial economics perspective, with its focus on using limited resources to maximize business value, and allows the products and methodology of economics to be applied to optimize decision-making. My hypothesis is that, for most video game organizations, their existing processes are insufficient for making appropriate management decisions because they do not validate the tacit assumptions behind those decisions. Three distinct causes behind this problem are at work: first, learning is restricted to past experience on a limited number of local projects within an organization, rather than an examination of projects across the industry; second, decision-making is concentrated in a limited range of actors, whose assumptions are difficult to question because they do not expose their decision process for validation; third, the "entertainment" nature of video game products and services leads to vague or ill-defined definitions of success that make assumptions difficult to falsify or validate. For a cultural or creative industry organization like a video game developer or publisher to become a learning organization, and thus competitive in a changing market, it must make the decision process transparent and allow for the use of data, both internal and external to the organization, to falsify or validate assumptions. Only when this is done can desired and actual results be compared against the wider industry and questioned, allowing learning to take place.

The focus on decision-making within the context of limited resources is in line with economic thinking. In particular, the field of managerial economics, introduced by Dean (1951), combines economics with decision making in a business context. It proposes the use of "the products (and more importantly the methodology) of economic

science to make better decisions." (Hill, 1989, p. 1) This research applies a managerial economics perspective to the decision-making process within the creative field of video game development and considers decision results in terms of their business value.

This research will propose a process for incorporating data from outside a video game firm's boundaries to spur internal knowledge creation that will lead to making more informed management decisions. The approach will be applied in four case examples through quantitative research into the results of one strategic innovation management decision, one human resource or "talent management decision", and two project management product scope decisions in the video game industry.

This research will propose an answer to the following question:

- How can an economic perspective that views decision optimization in terms of making the best use of limited organizational resources allow for the use of data from the wider industry to question assumptions and improve video game business management decision processes?

To demonstrate the usefulness of the proposed approach, this research will provide examples of the process in use with case examples to answer the following three questions:

- What is the state of intellectual property exploitation and exploration strategies in innovation and business management practices within leading video game organizations and how are those strategies changing?
- What role do women play in making creative decisions within video game development organizations and how does this compare to video game consumer demographics?
- How do the product scope decisions made in video game project management reflect what provides value to consumers?

This research contributes to the field of knowledge science by providing insight

into the ways that KDD approaches like data mining can verify or improve tacit knowledge and assumptions involved in decision-making processes within the creative and cultural industries, focusing on the video game case. The creative and cultural industries rely primarily on the tacit knowledge of decision makers to create value through symbolic products and thus provide a rich source for research because these industries have, so far, mostly relied on the "creativity" and tacit knowledge of individuals to define and create value for their organizations. However, the low barriers to entry in industries that rely on intangible capital like tacit knowledge to create value also mean they face high levels of competition when they grow. As demonstrated by the large numbers of entries and exits alongside long-running organizations in the video game industry, some tacit knowledge is "more valuable" to a video game organization as a business, which leads to the need for its verification and organizational learning. The perspective provided by the field of managerial economics, with its focus on optimizing the decision-making process and employing limited resources for the greatest business results, is critical for allowing data to inform the decision-making process in a creative industry, such as the video game industry, where tacit knowledge from prior successes and artistic vision often stand in place of a rational decision-making process. However, the proposed process recognizes that creative decisions are complex, information is incomplete meaning that rationality is "bounded" (Simon, 1957, Simon, 1972), and tacit knowledge is the source of most of the value in the symbolic products that are produced in a creative industry like video game development. The proposed process suggests a "data-informed" – where data is used to falsify or validate tacit assumptions – rather than a "data-driven" approach – where data is used to make the decisions.

In addition to the academic contributions of this research, the practical implications are also valuable to practitioners in the video game and other creative and cultural industries. Research into methods for improving decision making within video game organizations is critical because the business has surpassed the movie industry and grown into a projected $150 billion business with project budgets in some cases exceeding $100 million. (Bleeker, 2013, Wijman, 2019) Poor decisions based on limited or outdated tacit knowledge could lead to the closure of a video game organization.

In order to understand why the research presented in this dissertation is so critical to the video game industry, some background regarding the difficult position of video game business organizations is required. From there, an overview of the research scope and objectives will be provided, followed by an overview of the dissertation.

1.1 Motivation and Background

The video game industry's worldwide revenues for the year 2019 were valued at around $150 billion (Wijman, 2019) and are projected to grow further in the coming years. (Figure 1-1) These revenues surpass the $40 billion movie industry (McClintock, 2017) and are roughly equivalent to the worldwide sporting industry's revenues. (Taylor, 2017)

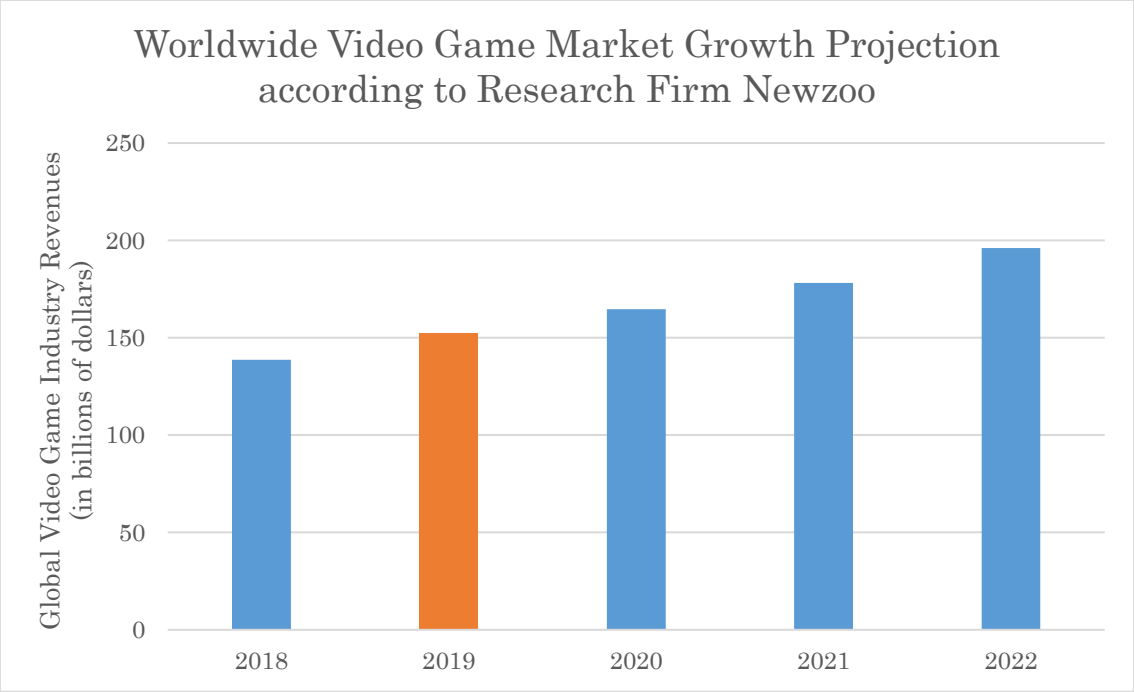

Figure 1-1. A projection for growth in video game worldwide revenues. (Newzoo, 2019)

So-called blockbuster "AAA" game development projects require years to develop, teams of hundreds of employees, and have development budgets exceeding $100 million per project with total budgets, when marketing expenses are included, reaching $265 million per project. (Bleeker, 2013) Even mobile games and independently development games with a level of polish require budgets in the millions. (Koster, 2018)

In such an environment, mistakes are expensive, which could drive video game organizations to grow more conservative when innovation is most required. In addition, the length of video game project development schedules and high employee turnover mean that decisions are made based on limited individual tacit knowledge acquired from prior experience on few video game projects. The limited demographic range of developers, who do not represent the demographics of the gaming population according to game developer and player surveys, could further exacerbate the difficulties of

making decisions informed by the wider market.

Research into quantitative methods for improving video games is growing, but quantitative research into the business side of video game development is still lacking. Qualitative research into the business side of video game development, including ethnographic case studies performed at Montreal-based game publisher *Ubisoft* by Cohendet and Simon (2007) has started to emerge; however, because these surveys focus on one, unique organization with a specific "culture", the results are difficult to apply to the development or production processes in other organizations. Another limit with applying qualitative research to business is the delay between the acquisition of knowledge and its application – often too late to keep up with a rapidly changing market. Whether an organization succeeds or fails depends on the context of its decisions within its industry. Data from the wider industry outside of the organization is required to test and falsify or validate the assumptions that go into decision-making. The goal of my research is to propose a data-informed learning process that can help falsify or validate these assumptions and to provide examples of the proposed process employed in four example cases, which respond to the need for more quantitative research into the video game business.

There is evidence to suggest that an investment in management can help improve the survival rate of video game companies. (Cabras et al., 2017) Some limited research into innovation and business management in video game organizations has begun, with Tschang (2007) exploring March's exploitation versus exploration debate within a single organization, and Ikuine's (2006) survey of the decline in innovation within the Japanese video game industry in the 1990s, but no quantitative studies exist that show what strategies the top publishers in the worldwide videogame industry are adopting, how those strategies are being reinforced, and how those strategies are changing over time. One facet of my research will be to quantify the intellectual property (IP) exploitation-exploration strategies of the top eight third-party video game publishers of console and PC games across the world by revenue, and, more importantly, how these strategies have changed over time in response to a changing business environment. This research will also include two large publishers that went out of business during the period in question. I will research and collate the complete video game catalogs from 1980 to 2018 for the ten video game publishers, then flag every game in the catalog as being either new IP, a sequel to existing video game IP, or a game based on external IP, such as movie or book properties. In addition, sales and critical rating data for long-running series will be collected and analyzed to determine how exploitation strategies are reflected in sales and ratings over the course of an IP

franchise series. By explicitly exposing these strategies, this facet of the research will provide a method for video game organizations to compare their portfolio decisions against the IP exploitation-exploration strategies of the wider industry.

Quantitative research into human resource or "talent management" and the demographics and experience of decision makers in video game organizations is also required to better understand who is making decisions and what factors could influence those decisions. My research into this area will use publicly available staff role data for 27 best-selling games representative of the top console and PC video game publishers by revenue in the period from 2000 to 2018, on which a gender analysis will be used to determine the ratio of men and women in different development and support roles, with a focus on the ratios in the roles with power or creative voice. In addition, I will analyze the demographic makeup of developers of the top-ten selling games by year from 2000 to 2018 to determine the presence of women in the top direction and production roles with the strongest creative voice. Better understanding in this area could allow organizations to correct possible shortcomings in the human resource side of their decision-making and knowledge-accumulation processes that are failing to serve their target demographic.

A third management practice, project management, also lacks quantitative research focusing on video game development organizations. What research does exist focuses on either the software aspects of video game development, such as that by Murphy-Hill et al. (2014), or on the difficulty of managing the interdisciplinary nature of video game development such as that by Deuze et al. (2007). While this research is also critical to successful video game project management, it focuses on quality control or human resource utilization. Despite controls for budget and schedule, scope remains unexamined within video game projects. Although research by Bauckhage et al. (2012) found that players tend to quit early in the games examined, there has yet to be an industry-wide examination of game consumption trends and "how much game is needed" to provide "enough" value to players. I will analyze game data mined from the over 30,000 applications listed on *Valve*'s *Steam* service at the time of the research, critical data from *Metacritic*, and sales data from *VGChartz* and analyze the collated results to calculate how many players are completing "single-player" content, and how the inclusion or lack of a "multiplayer" feature impacts critical ratings and sales. By demonstrating how both content and functional scope can be quantitatively assessed, this research provides methods for video game project managers to decide an appropriate scope at the outset of their projects.

Each facet of research focuses on quantifying a different management area in

video game development: strategic innovation management, human resource or "talent management", and project product scope management, in order to show how data and KDD techniques can be used to confront structural inertia and improve decision processes throughout video game organizations and other cultural industry organizations, which have relied on the tacit knowledge their employees have accrued through experience on a limited set of projects. Four cases from these three management areas were chosen because they represent how the process can be employed in questions regarding "what" and "why" games are made, in the case of strategic innovation management, "who" makes games, in the case of human resource or "talent management", and "how" games are made, in the case of product scope project management. In cases like the cultural industries, where "nobody knows" what will sell (Caves, 2000) and "value is subjective" (Bilton, 2007), quantitative techniques are invaluable for correcting tacit knowledge that may no longer reflect the rapidly changing markets of these industries.

1.2 Scope and Objectives

The goal of this research is to present an approach to improving decision making in the video game industry through the use of KDD techniques. The results of decisions are made measurable in the context of a business organization if a managerial economics approach is taken. Although "economics" in popular use is associated primarily with monetary decisions, it covers non-monetary decisions as well. Robbins (1932, p. 15) defined economics as, "the science which studies human behavior as a relationship between given ends and scarce means which have alternative uses." For this research, the ends are video game products, and the scarce means in the researched examples include the number of projects an organization can maintain at any one time, human resource limitations, and the project management limitations of software product content and functional scope.

There are many different areas of business management that require decision-making, such as: financial management, marketing management, human resource management, strategic management, production management, operations management, service management, and IT management. (business.com Editorial Staff, 2012) This research will provide four cases of the proposed approach covering a strategic innovation management decision – whether to explore or exploit intellectual property; a human resource diversity management decision – whether current practices are allowing women the same opportunities as men; and two production project scope management decisions – whether the amount of content being provided to players is too

much, and whether an online "multiplayer" mode is worth developing in every case. However, there are many business decisions covering a range of management areas, such as the ones listed above, in a video game organization and other creative industry organizations that could benefit from the same approach even if they are not covered by the cases in this research.

This research also focuses on decisions and the results within publishers and developers of "console" and "PC" games, which excludes publishers and developers of "mobile" games. Mobile games demonstrate many notable differences, particularly with the business model. The value proposition, creation, delivery, capture, and communication all differ (Rayna and Striukova, 2014), making it difficult to compare them and their publishers to console and PC games, and, although outside the scope of this research, deserve to be explored as a separate subject in future research.

For the purposes of this research, the classifications of games covered in each chapter vary based on the availability of the data required for analysis and the focus of the analysis. AAA, AA, and A level, "PC game" titles are covered in every chapter of the research, while the focus on activities in the top-revenue earning publishers limited the data selection to AAA, AA, and A level titles for Chapters 5 and 6, and the availability of achievement data at the time of the research limited the data selection to the PC platform for Chapters 7 and 8. (Table 1-1) Also, the number of games analyzed varies depending on the scope of the research and the availability of data. The difference in number of applications from *Steam* analyzed in Chapter 7 (31,964 applications) and Chapter 8 (34,263 applications) is due to the difference in timing between when the research was conducted.

Table 1-1. The categories of games covered by the research in Chapter 5's exploration-exploitation analysis, Chapter 6's gender analysis, and Chapter 7 and 8's product scope analysis.

	Mobile	Console	PC
AAA	-	CH 5, 6	CH 5, 6, 7, 8
AA, A	-	CH 5, 6	CH 5, 6, 7, 8
Indie	-	-	CH 7,8

While this research focuses on the case of the video game industry, the same process can be extended to testing tacit assumptions in the wider cultural and creative industries, where tacit knowledge based on prior experience is the primary decision-making factor and source of value, which is mostly symbolic.

1.3 Overview of Dissertation

This dissertation contains nine chapters following the flow presented in Figure 1-2. The individual chapters contain the following content.

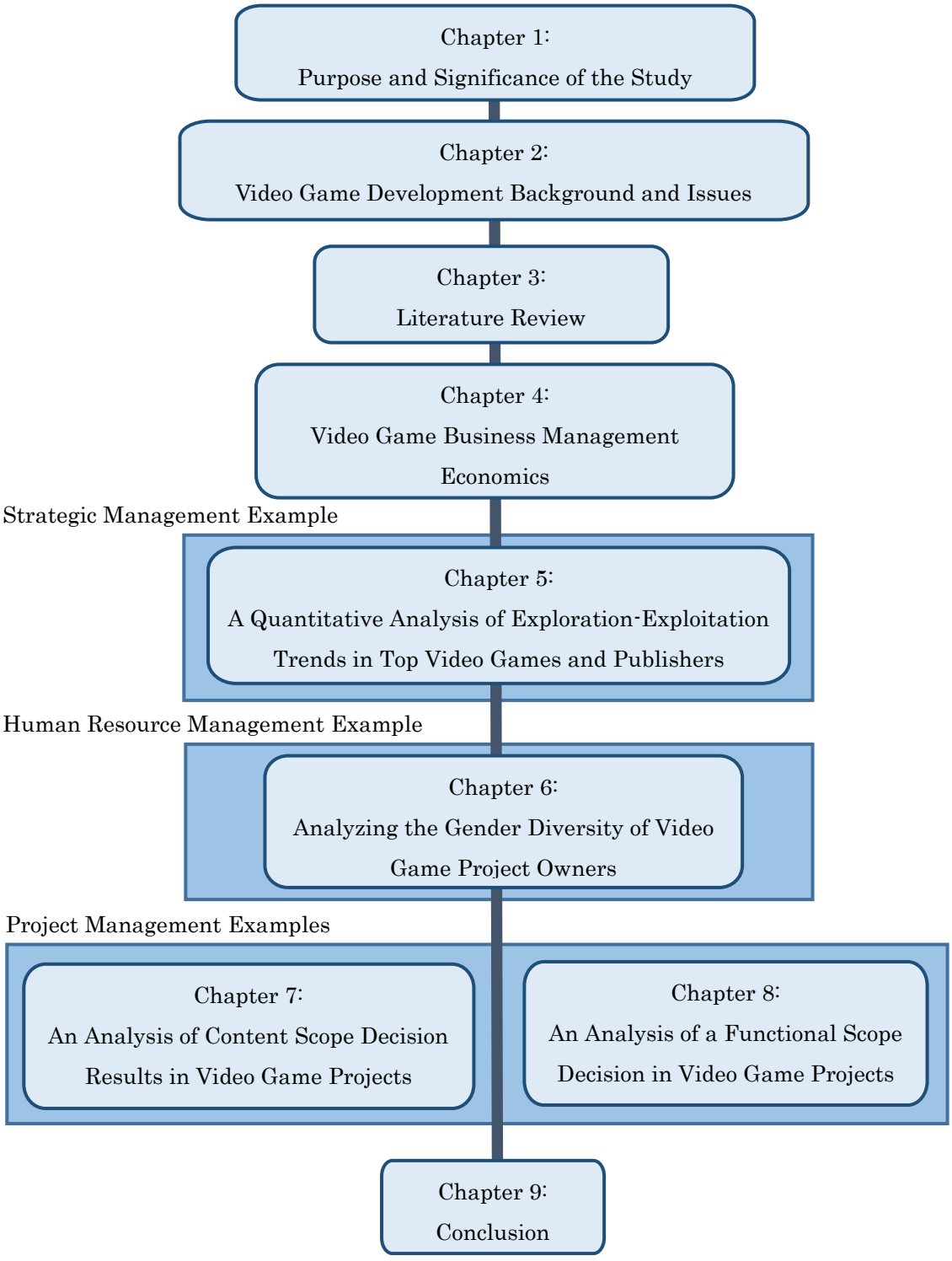

Figure 1-2. An overview of the dissertation content.

- Chapter 1: Introduces the purpose and significance of this study, including the motivation and background, the scope and research objectives, and presents an overview of the dissertation's structure.

- Chapter 2: Presents an overview of the video game production process and a detailed description of the background required to understand the current issues in video game development this research addresses.
- Chapter 3: Presents a review of relevant prior research and literature including that on the creative industries, project management, knowledge management with a focus on knowledge discovery, and consumer value.
- Chapter 4: Proposes a learning process for video game organizations that attempts to falsify tacitly held assumptions using data from sources external to an organization. It introduces how this process will be applied to the examples in business management decision-making in the chapters to follow.
- Chapter 5: Analyzes the data from 6,222 console and PC video games from ten of the top third-party publishers over the course of 38 years to discover how innovation strategies have shifted from relying on exploration to exploitation as risks rise and how those strategies are reinforced even if they have limitations.
- Chapter 6: Analyzes the staff list data for 14,265 people from 27 representative "AAA" best-selling games to explore the level of gender diversity in project owners and developers with the creative voice to influence project decisions and provide new sources of innovative ideas.
- Chapter 7: Analyzes 31,964 applications released from 2005 to 2017 to discover content consumption trends, with a focus on the completion of "main-path", "single-player" content to discover whether the product content scope reflects the needs of consumers.
- Chapter 8: Continues analyzing video game project scope decisions based on 34,263 applications released from 2005 to 2017, this time with a focus on an important functional scope decision, "multiplayer" functionality, and whether it provides enough value to offset the costs and risks involved in its inclusion.
- Chapter 9: Concludes the dissertation by reviewing the results and examining the contributions made to existing research as well as practical applications to the video game industry with possible applications to other creative industries.

2. Video Game Development Background and Issues

To provide background into why the research presented in this dissertation is critical to video game developers and publishers, this chapter will provide an overview of how games are made, followed by an overview of the current state of the video game business, with a focus on the hardware game "console" and PC game business. Then it will introduce the issues and complications involved with video game project management, introduce human resource or "talent management" issues in video game development, and introduce project management issues in video game software development. Finally, it will address the current limitations of organizational learning within the video game industry.

2.1 Video Game Development

Development of video games is an interdisciplinary process that shares the characteristics of both traditional software development and artistic creation. Before a video game reaches the market, it proceeds through several steps from the original concept proposal to the final "release" as a product in the market. Before a video game reaches the market, it often must pass several stages of stakeholder or gatekeeper inspection, particularly when a video game "publisher" – a company that often shoulders some or all of the development budget and handles the sales and marketing of the product in exchange for some or all of the profits – is involved.

2.1.1 Development Process

The specific process through which a video game is moved from idea conception to release into the market varies by organization; however, development typically proceeds through some form of the following phases:

- Proposal Phase

  In organizations where business managers or producers decide whether or not to pursue a video game project, this phase is where an idea for a video game is proposed and either accepted or rejected.

- Concept Phase

  In this phase, the core idea espoused in the proposal phase is detailed to the extent necessary for the ideas to be tested in software.

- Prototype Phase

  There may be several prototype phases; however, the essential purpose of the phase remains: to prove the validity of the video game concept in software with a common secondary objective of identifying the risks of development.

- Development or Production Phase

  When a product enters the development or production phase, organizational resources are committed to the project's execution. This may also include a quality assurance step, where the functionality of the video game product is tested to ensure bugs are either fixed or documented before the product reaches the public.

- Release

  This phase marks the release of the video game product and can be accompanied by marketing efforts to better sell the title.

- Post Release Phase

  More recently, after the introduction of the internet, the ability to update video game software or offer free or paid expansions to software has resulted in a post-release service phase. The notion of games as a continuing service, rather than a final product, has been called "games as a service". (Schreier, 2017a)

In most cases, the core idea of a video game idea is developed in solitude by one creator and then, when the originator is ready, pitched to other creators or staff in an organization. (Kultima, 2010) The phase at which a project becomes part of an organization's formal development process and receives an official budget and support varies by organization. Like other new product development, a large amount of work is involved before a game enters production. Markham et al. (2010)'s three roles of "champion", "sponsor", and "gatekeeper" are applicable to new video game product development and the need to get an idea formally approved; however the person filling each of the roles varies by organization. One common pattern is that a director or producer will originate the idea and be its champion, while either a producer, a senior producer, or an executive producer will serve as the primary sponsor pitching the idea to

business or studio management gatekeeper to get the project approved and obtain resources for its development. One difference with other industries is that the product's value is mostly symbolic, and its value is the result of a creative vision, so the originating "champion" tends to retain a strong influence until the product's release. Like software development, as a project moves through phases, the costs of making changes to specifications or scope rises. (Everett and McLeod, 2007, p. 14) This is true even in the case of de-scoping, or reducing scope. (Wiegers, 1999)

2.1.2 Game Features and Genres

Like movies or books, there are many ways to classify games into "genres", and it should be noted that any rigid classification attempt is likely to fail as games can contain elements from multiple genres; however, genres allow consumers and researchers to categorize games with shared elements and hold expectations with regard to the content contained (Clarke et al., 2017). For the purposes of this research, genre follows the categories defined by *Valve Corporation*'s PC game retail service, *Steam*. Following the genre "tags" divides game applications on the service into the following categories:

- Indie – a game created by a developer without the support of a large publisher
- Action – a game where reflex reactions are required to play
- Adventure – a game that contains some action-based elements but focuses on exploration
- Casual – a game that does not require deep experience with games to play
- Racing – a game that involves racing other computer opponents or players to be first to reach a goal
- RPG – a "role-playing game" or a game where the focus is on increasing the "power" or "experience" of the video game avatar
- Simulation – a game that relies on a deep rule set or calculations to simulate an experience
- Sports – a game that reenacts a sport, such as baseball or soccer
- Strategy – a game that tests the logic of the player

One of the Steam genres "Indie" is less a video game genre and more of a category label based on the size and financial means of the developer. The other most

common label based on the budget and ambition of the video game project is “AAA”, which is used to denote blockbuster titles. Other less-common labels include “AA” and “A” to represent games by mid-tier publishers which have larger production values than Indie games, but lack the budget of AAA games.

There are other ways beyond genre to classify games. One other method is based on the number of players required for the experience. The traditional, solo experience is labeled “single-player” as opposed to games involving multiple human players, “multiplayer.” So-called multiplayer games can further be divided into “co-op” if they require players to cooperate with each other to reach some goal, or “competitive” or “vs” if they require players to compete against each other to obtain some goal. Before network connections became ubiquitous, “multiplayer” games required its human players to be physically present in the same room, but with the advent of modems and eventually broadband internet, multiplayer games can be played either in the same room or with players around the world. In extreme cases, such as the “massively-multiplayer online” genre, millions of players subscribe to join the same virtual world; however, multiple servers divide the population into more reasonable segments for processing sub-populations. Competitive online shooters and “multiplayer online battle arena (MOBA)” games also boast large populations of gamers who log in to compete for the highest rank, with some of the most popular games holding “e-sports” events where top players compete for money. *Tencent*, the largest video game publisher in the world by revenue (Newzoo, 2018), owns the video game studio, *Riot Games*, which is responsible for *League of Legends*, the “most-played PC game in the world.” (Riot Games, 2019) Unlike most single-player games, online-based multiplayer games require operating costs, including servers and community management, in addition to the original development costs. Games that come with both single-player and multiplayer content have to incur the costs of developing both features. The primary benefit of a multiplayer feature is that it allows the developed game rules and systems to be used by multiple human players who can respond and react to each other’s play, transforming the game into a social experience rather than the static, solo experience of a single-player only game.

Another way of classifying games is by the hardware platform required to play them: “mobile games”, which can be played on mobile phones, smartphones, and tablets; “console games”, which can be played on hardware like *Nintendo*’s *Switch*, *Sony*’s *PlayStation 4*, or *Microsoft*’s *Xbox One*, and “PC games” which require a personal computer. According to research company *Newzoo*’s revenue breakdowns, mobile games account for roughly 45% of all video game income, followed by console games with 32%,

and PC games with 23%. (Newzoo, 2019) However, there is much crossover in development efforts, particularly between console and PC games, with many developers releasing the same game on both platforms. Mobile games do demonstrate many notable differences, particularly with the business model (Rayna and Striukova, 2014), making it difficult to compare them and their publishers to console and PC games, and, although outside the scope of this research, deserve to be explored as a separate subject in future research.

2.1.3 Publishers and Developers

The boundaries between video game "publishers" and "developers" are blurry, but typically a developer is the entity – person or organization – that "creates" the game, while the publisher is the entity that, as Readman and Grantham (2006) put it, "brokers" the game and is responsible for its release in the market. In some cases, the same organization can be both a developer and the publisher of its own games if it possesses the competencies to perform both functions.

Specific to the video game industry, with a divide between video game "software" and the "hardware" required to run the software, "first-party" publishers and developers, such as *Microsoft*, *Nintendo*, and *Sony*, are entities that produce both hardware and the software that runs on it, while "third-party" publishers and developers, such as *EA*, *Activision-Blizzard*, and *Square Enix*, produce software that runs on hardware produced by another company.

Readman and Grantham (2006) noted that the current phase of the video game industry is "one of intellectual property development and management." In the video game industry, as in other cultural or creative industries, "intellectual rights are the main form of capital." (Lash and Urry, 1994, p. 136) Publishers are responsible for intellectual property management as they are the economic entities trying to maximize the profits that can be obtained through the use of this intellectual capital, while developers, as the name suggests, are responsible for intellectual property development.

2.1.4 Stakeholder Overview

Many stakeholders are involved in the development of a video game. The primary stakeholders on an individual video game project are the producer, who is typically responsible for the business and marketing aspects of a video game product, and the director or lead game designer, who is typically responsible for the creative

aspects of a video game product, although the roles can overlap depending on how they are delimited within an organization. Within the team, stakeholders include the various functional leads, who are typically responsible for their area within a video game project – including the art director as the person responsible for a game's visual presentation, the sound director for a game's auditory presentation, the technical director or lead engineer for a game's software construction, and the game director or lead game designer for a game's design. In cases where an organization has a matrix organization, functional managers may oversee hiring, promotion, and employee development, although they are not directly involved in the creative decision process.

Outside of the project team, but still within the organization, stakeholders include business managers, who are responsible for the performance of their video game portfolios, marketing staff, who are responsible for predicting sales and ensuring those sales targets are met, human resource (HR) and facility staff, who are responsible for ensuring teams have the resources they need to develop and publish games, and quality assurance (QA) staff, who are responsible for promoting the bug-free performance of the product. Business managers may also be executives, who are responsible for the financial performance of their organizations and can influence the culture and business management decisions being made. Beyond the confines of the organization, in the case of an incorporated entity, shareholders are an important stakeholder to whom the executives are held responsible if the company does not perform to expectations.

In terms of the cases provided by this research, the primary stakeholders whose assumptions drive decision-making are described in Table 2-1.

Table 2-1. The primary stakeholders whose tacit assumptions drive decision-making in the management areas described in the four cases in Chapters 5, 6, 7, and 8.

Chapter	Management Area	Primary Decision-Makers
Chapter 5	Strategic Innovation Management	Business Managers, Executives
Chapter 6	Human Resource / "Talent Management"	Functional Managers, Producer, HR
Chapters 7 & 8	Project Management	Director, Producer

2.1.5 Hit Games and Portfolio Risk

The video game industry is hit-driven, like many other creative industries such as movies or music. (Bakker, 2010, Hirsch, 1972) In order to generate blockbuster "AAA"

hits, large budgets, in some cases surpassing $100 million for development alone (Bleeker, 2013), are required to generate the content and marketing behind games that will stand out in the market and become a best-seller that year. This leads to the video game industry being a winner-take-all market. (Frank, 1995)

The production of hit games drives growth in these businesses, which depend almost entirely on the sales of video game products to produce profits. For a video game company to earn higher profits, it must either sell more units or reduce costs. When developers compete in established video game "genres", they compete against other video game companies developing games in the same genre and the need to stand out to consumers drives development costs higher. The only way to drive growth is through differentiation – either through the product itself or through the way it is distributed or marketed. (Ernkvist, 2008) Recent video game hits which drove new growth within the video game industry, such as *Minecraft* and *PlayerUnknown's Battlegrounds*, did not come from the major publishers but emerged from independent developers engaged in exploring new experiences rather than exploiting existing properties. Kerrigan et al. (2019) made the observation that failure and success in creative activity are not opposites, but rather complimentary and that it requires repeated risk-taking behavior to discover success. Given the "hit-driven" nature of the video game industry and the fact that "nobody knows" (Caves, 2000) what will succeed, risk-taking and failure is essential for discovering the next hit and producing growth, particularly when the rising costs of game development will reduce profits in a long-selling series if sales remain static.

The concepts of exploration of new organizational competencies and exploitation of existing organizational competencies introduced by March (1991) can take several forms within video game development, including but not limited to: production and process competencies, hardware platform competencies, software competencies, genre competencies, and marketing competencies. However, the analysis by Tschang (2007) showed that video game publishers are characterized by "their focus on IP" and suggested that creative industries in general are "characterized by the continual development and renewal of intellectual property." In other words, the development of IP is a critical competency for any creative industry organization as intangible "intellectual property" provides the primary source of value – value that can be generated through exploring the development of new intellectual property or exploiting competencies around existing intellectual property.

2.1.6 Video Game Professionals and Career Advancement

Video game development is a difficult process that, due to the combined requirements of art and technology, relies on a "higher skill set than on a film, where catering, set design and construction, production, casting and editing are separate, contracted-out entities." (Wade, 2007) These requirements translate into a need to hire highly specialized, professional employees ranging from those with design skills in 3D computer graphics modeling or animation to engineers who can write efficient enough code to allow highly realistic expression or complicated AI behavior. Video games are also project-based, which means employees are often hired as a project scales up and released when a project scales down. This leads to "boundaryless" careers, where employees are hired on an as-needed basis for their professional skills. (DeFillippi and Arthur, 1994) The project-based nature of video game development is one way video game organizations, like other creative industries that rely on projects, avoid some of the risks involved with developing video games – by placing the burden of risk on the employees at the bottom of the hierarchy. (Mills and Horton, 2016, p. 124)

Development teams do not typically have a need for generalists, and career advancement is often decided within a functional hierarchy – engineers decide which engineers should become leads or managers, for example. Without human resource management intervention, hiring and promotion are left to the subjective opinions of existing specialists in the organization. (Prendergast and Topel, 1993)

2.1.7 Marketing, Human Resources, and Support Roles

Marketing in the video game industry, as well as other creative industries, differs significantly from marketing in traditional industries because of the experiential nature of the product. In other industries, marketing often provides input into the product development process by defining the needs of customers, which it uses as a base for determining what products should be developed; however, in the creative industries, consumer needs are ill-defined. Instead, product concepts are developed by creators, such as artists or game designers, and marketing is focused on how best to sell the resulting creative product to customers. Although the role of marketing is typically relegated to the back-end of the product development cycle in video game development, it still can exert influence over the R&D process at certain stage gates by predicting sales, which, if low enough can lead to the cancellation of the remaining development effort by organization management.

Another support role, the human resources (HR) division or team, may not have direct control over creative decision-making in games, but can provide the framework and rules for deciding who is hired, promoted, or retained in organizations. Within HR, "talent management" is a collection of "interrelated workforce-management activities concerned with identifying, attracting, integrating, developing, motivating, and retaining people" and effective talent management is essential for creating a competitive advantage. (Heinen and O'Neill, 2004)

As with marketing and HR, other "support" roles do not typically have creative voice in the development of video game products – creative voice is concentrated in the hands of developers, with the strongest creative decision-making power held, as in movies, by the director and producer.

2.1.8 Critical Reception

Various media outlets such as magazines and web sites review video game products and often report grades or scores as an attempt to guide consumers to "high-quality" games. Launched in 2001, website *Metacritic* aggregates review scores from multiple sources into one overall *Metacritic* score from a low of 0 to a high of 100. (Metacritic, 2020) Game publishers have since used Metacritic scores as a barometer of the "quality" of the games they publish in the belief that quality leads to higher sales. (Alexander, 2009)

High critical scores do not necessarily lead to high sales, nor do low scores necessarily result in low sales as demonstrated by former publisher *THQ*'s title *Homefront*; however, review scores and sales have demonstrated a strong enough link that they can lead to a loss of confidence in the publisher, as was true in the *Homefront* case, where low scores caused *THQ*'s stock price to fall. (Schreier, 2011) Greenwood-Ericksen et al. (2013) performed a quantitative analysis demonstrating the validity of the correlation between *Metacritic* scores and sales; however, as the authors stated, there could be several reasons: scores could predict sales, scores could lead to sales, or high scores and sales could both be influenced by a third factor. Although the causal factors remain undetermined, the correlation between a positive critical response and sales is strong enough for the industry to consider critical response as a business factor. In some cases, bonuses are tied to critical score benchmarks, such as in the case where developer *Obsidian Entertainment* was unable to collect the contracted bonus from publisher *Bethesda Softworks* because their 84 score fell one point short of the contracted 85 target. (Gilbert, 2012) Whether or not critical scores lead to higher sales,

video game businesses prefer earning high critical scores, which are viewed as a benchmark of their product's quality.

2.1.9 Institutional Effects

Within the creative industries, cultural industries including video game development tend to split into the two extremes of large "majors" organizations and small "independents" organizations without much in the middle. (Peltoniemi, 2015) In video game development, large publishers control most of the video game market, with an estimated 77% of global game revenues being captured by the top 25 companies. (Wijman, 2018)

The project-based nature of the video game industry leads to "boundaryless careers" (DeFillippi and Arthur, 1994); employees change organizations many times over the course of their careers as projects scale up and down. As employees move between organizations, they carry the knowledge they have accumulated with them. (Bird, 1994) Informal knowledge sharing through this frequent exchange of human resources as well as formal knowledge sharing through events like the *Game Developers Conference* (*GDC*) or the *Computer Entertainment Developers Conference* (*CEDEC*) for game developers and the *Design Innovate Communicate Entertain* (*D.I.C.E.*) *Summit* for leaders and business managers give video game organizations opportunities to study each other and emulate practices perceived to be successful in other organizations. Because "nobody knows" (Caves, 2000) what will sell, and there is a higher tendency for organizations to grow similar as the relationship between means and ends grows uncertain because they attempt to model what they perceive to be successful in other organizations. (DiMaggio and Powell, 1983) Like other cultural industry firms, video game organizations seek to find an "optimum level of differentiation in order to offer a unique product, but at the same time remain sufficiently similar in order to remain legitimate." (Peltoniemi, 2015)

2.2 Video Game Business and Innovation Management

According to market research company *Newzoo*'s Global Games Market Report, video game industry revenues were valued at around $152.1 billion in 2019 and are projected to continue growing. (Wijman, 2019) While the video game industry grows, game development studios and even some major publishers, such as *Midway* and *THQ* have gone out of business. Video game developers face not only pressure from other

developers, but from other entertainment products. In these market conditions, some companies are only one failed project away from bankruptcy.

Increased demand for graphic "realism", and the pressure to remain ahead of the growing competition have driven video game budgets higher. Ralph Koster analyzed the budget data from a sample of 250 games from 1985 to 2017 and found that budgets were growing by a factor of 10 every decade. (Koster, 2018) There is an "innovation dilemma" because creativity is behind the value of entertainment products, but shorter life cycles, rapidly changing technologies, and quickly outdated business models force developers to perform a balancing act between creating an innovative product and staying efficient in a competitive market. (Hotho and Champion, 2010)

Within the development budget, staff costs typically comprise the bulk of budgets, and one industry standard used to estimate staff costs is $10,000 per person per month, confirmed in Pearson (2014). Team sizes for the hit "AAA" games used in the staff list analysis in Chapter 6 were counted and provide a perspective of how team sizes have grown over time and over the course of an intellectual property (IP) franchise series. (Figure 2-1) At least for "AAA" titles making top-ten best-selling game lists, development team sizes are growing at an accelerated rate.

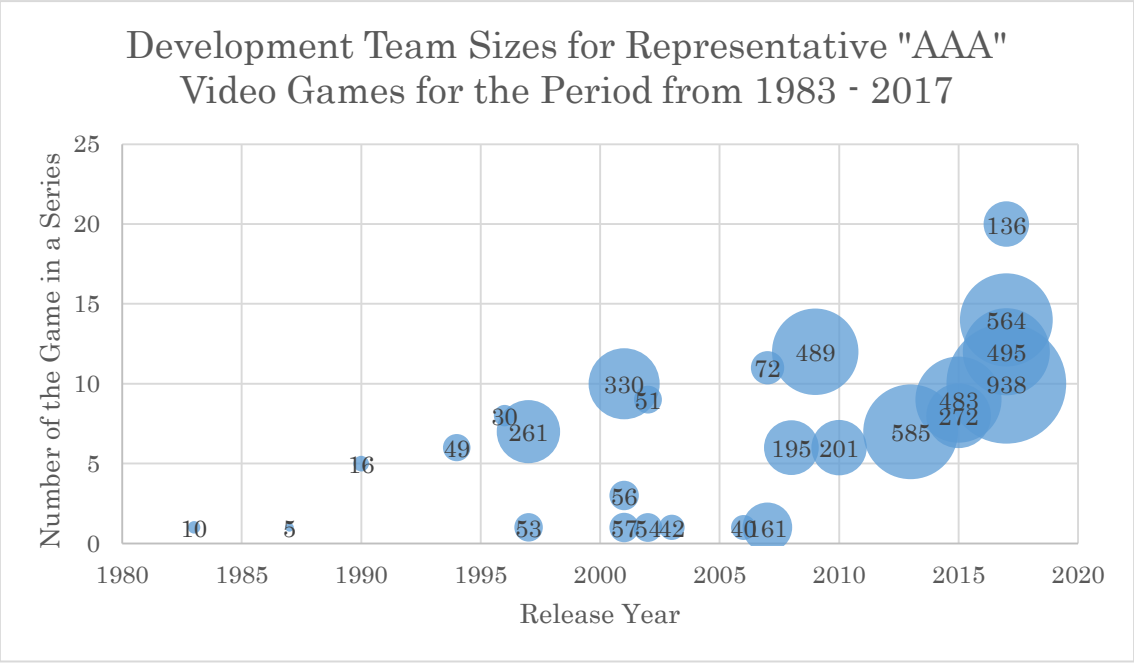

Figure 2-1. Development team sizes for the "AAA" video games sampled in the period from 1983 to 2017. The y-axis represents the numbering of the game if it is within an intellectual property (IP) franchise, while the x-axis represents the release date. Sizes of the bubbles are related to the size of the development teams (support staff not included).

Video game development budgets have reached $265 million, with $100 million for development alone (Bleeker, 2013). Risks are rising, and placing bets on a video game project is beginning to resemble gambling more than a stable business model. As early as 2008, *Electronic Entertainment Design and Research* (*EEDAR*) found that only 20% of games that reach the market will return a significant profit. (Irwin, 2008) Institutional characteristics, such as imitating and learning from other publishers and developers and sharing of tools and methods, are one way organizations are mitigating the risk. (Tschang, 2007) Tschang (2007) noted that, in addition to financial risks, increasing product complexity is another reason that "gatekeepers" deciding whether to pursue a project are likely to prefer incremental innovations. One incremental innovation as a response to the rise in complexity and risk of game development is a rise in the number of sequels based on previously successful games or intellectual properties (IP), the details of which I will analyze in Chapter 5.

2.3 Video Game Human Resource Management

Two significant issues facing human resource or "talent management" that impact knowledge management in the video game industry are employee turnover and diversity. According to the 2019 survey of game developers conducted by video game development site *Gamasutra*, nearly two thirds (64%) of employees within the video game industry have only been there for less than a decade, with nearly half (46%) being there for less than six years. The high rate of turnover makes it difficult to retain the tacit knowledge accrued by employees in the course of their creative work and gives them few projects to generate experience given games can take years to develop. Like other creative industries, working conditions are unfavorable, except to an elite core at the top. (Krätke, 2012) Even as early as 2004, an *International Game Developers Association* (*IGDA*) report termed the extreme levels of turnover "catastrophic" to the industry as it struggles to face growing challenges that require expert leadership. (Bonds et al., 2004) The *IGDA*'s 2017 survey found that, even for non-freelance employees, the average employee had changed employers 2.2 times in the last 5 years. (Weststar et al., 2018) Game developers are not only changing employers but leaving the industry behind. High turnover leaves behind few veterans experienced enough to handle such a complex and ever-changing market. (Deuze et al., 2007) Most of the knowledge workers that remain have only a few projects worth of experience to construct the tacit knowledge required to make critical creative decisions.

Diversity issues continue to be a problem, despite the role it plays in helping

with innovation by providing a wider range of knowledge and experiences to draw upon. (Parrotta et al., 2014) In another creative industry, movies, Perretti and Negro (2007) showed how Hollywood benefited from a combination of newcomers and veterans. However, like other creative industries ranging from the movie industry (Smith et al., 2018) to the audio industry (Mathew et al., 2016), the fashion industry (Brown et al., 2018), or the architectural industry (Equity by Design Committee, 2016), the video game industry faces a particularly deep problem with the lack of women, particularly in roles at the top. Only 19% of respondents to the 2019 *Gamasutra* survey and 21% of respondents to the 2017 *IGDA* survey were women. Although gender diversity is only one facet of diversity, the games being produced by the industry largely reflect the demographics of the developers, leaving women gamers unserved. In a sample of 150 games, Williams et al. (2009) found that 81% of video game characters were male, a ratio that rises when the focus is on the lead character. The women who are in the video game industry face discrimination issues such as the "bro cultures" reported at companies like *Riot Games*. Potanin (2010) made the observation that, "in a self-perpetuating cycle, game characters reflect the aspirations of game makers and in turn inspire game players" and Williams et al. (2009) observed that, "games and gender work as a cycle: games feature more males and so attract more young males to play." Despite this, female gamers make up around 46% of players, at least in the U.S. video game market. (Entertainment Software Association, 2019) From a business management perspective, this leads to a critically underserved market for video games that can only be corrected if active steps are taken to ensure diversity in the creative voices contributing to game development.

The perception by the existing development specialists of who will best fill a role is often the deciding factor in hiring and promotion. The risk inherent to this form of specialization and self-judgment is that it opens the hiring and promotion process to self-selection bias – the perception of demographic similarity has been found to influence decisions regarding candidate hiring. (Graves and Powell, 1995) Schneider (1987) described the "Attraction-Selection-Attrition (ASA) Cycle" where an organization grows less diverse over time because they attract the kind of people who create the organizational culture and turn away or turn off the kind of people who would change the culture. With regards to organizational attractiveness, having more women increases the attraction of the organization to potential female employees. (Maas and Torres-Gonzalez, 2011) In a creative industry like video game development, there are few objective measurements to ensure unbiased review, leaving human resource appraisal up to the subjective judgment of evaluators. Without human resource

management intervention, self-selection bias is difficult to correct because hiring and performance evaluation are subjective. (Prendergast and Topel, 1993) There is also the issue that hierarchy roles tend to be gender segregated, with men tending to fill hierarchy-enhancing roles, which earn more and have more power. (Pratto et al., 1997) Once discrimination leads to a wage gap, this discrimination becomes self-perpetuating as women are more likely to drop out of the work force and be thus unable to reach senior positions with higher pay. (McCaffery, 1993)

Ensher et al. (2001) stressed the importance of addressing discrimination because it affects "key areas of human resource management and development" including "recruitment, compensation, organizational culture, and employee relations." Discriminatory practices, if they persist, will also affect "organizational commitment", "job satisfaction", and "organizational citizenship behavior" (Ensher et al., 2001) providing a business incentive for implementing HR policies to correct discrimination. Simply closing the gender gap is not enough to obtain the benefits of diversity and active human resource management is required. (Jayne and Dipboye, 2004) Specific to a creative industry, such as video game development, diversity has a positive impact when the "task can benefit from multiple perspectives and diverse knowledge, such as innovations, complex problems, or product design" based on the broader "range of knowledge, skills, and contacts" that help solve the given problems. (Williams and O'Reilly III, 1998) HR intervention is also required to ensure that the workforce is trained in diversity management so that they can turn the diversity of their members to an advantage. (Kochan et al., 2003) Kochan et al. framed the business case for diversity as, "Organizations that invest their resources in taking advantage of the opportunities that diversity offers should outperform those that fail to make such investments." Ali et al. (2009) showed that gender diversity has a notable positive effect on business results in the case where a business relies on intangible resources such as employee creativity or "market insight" to generate value, as opposed to traditional manufacturing industries that focus on more tangible resources.

Essential to implementing a successful diversity initiative is to "establish metrics and evaluate the effectiveness of diversity initiatives." (Jayne and Dipboye, 2004) Jayne and Dipboye noted that metrics are useful in ensuring that "scarce resources are devoted to areas that will benefit most," and "establishing metrics and evaluating the effectiveness of diversity initiatives will allow organizations to make data-driven decisions about how to leverage resources most effectively." Jayne and Dipboye made several relevant observations to the research conducted regarding the measurement of gender diversity in the video game industry, namely that organizations

should measure the demographic makeup of its employees and compare that to the available labor market to identify specific areas where human resource management processes might be failing.

The extent of gender diversity issues, particularly in positions with creative power, in "AAA" game development will be explored in Chapter 6.

2.4 Video Game Project Management

Video games are similar to other media development industries, which are traditionally project-based. (DeFillippi, 2009) Caves (2000) pointed out that project-based production is employed in creative industries in a response to the high-risk environments as a way to minimize fixed costs and control potential losses. For media producers who do not know in advance which products will be successful, every project is an experiment – an attempt to test the market and see if the assumed value proposition meets consumer demands. (Lorenzen and Frederiksen, 2005) These experiments can grow expensive, and poor production practices are hurting the video game industry. As Della Rocca (2006) stated, these practices are "stealing the industry's ability to innovate and reinvigorate itself with fresh ideas," "limiting our ability to attract new and diverse talent," "robbing us of our experienced creators, who leave us with their hard earned tacit knowledge in tow," and are "restricting our ability to reach broader audiences and create games with ever more cultural significance."

The reason that poor practices are becoming more of a problem is that video game projects are growing in budgets and in team size. Game development has grown complex, and the projects have become "unwieldy" for the teams working on them. (Gregory, 2008) They embody the difficulties inherent to software development as well as the difficulties involved in producing artistic work. (O'Donnell, 2014) The difficulty of producing a video game is also compounded by the fact that they require interaction from the consumer. (Kohler, 2012) Developing video games requires a careful balance of "creativity" and "constraint" – too much creativity heightens risk and lowers efficiency, while too much control prevents innovation. (Cohendet et al., 2014) Efficiencies are also difficult to obtain in video game projects because a dominant design has yet failed to emerge both in hardware and in software, which generates the high levels of risk that have led to so many entries and exits to the industry. (Peltoniemi, 2008) In fact, games continue to grow more difficult to develop as the demand that they be more visually realistic continues to rise. (Sapsed et al., 2007) Efficiency is critical, but despite the need to improve project management processes, the video game industry keeps much of how it works secret, with many of its processes "opaque". (O'Donnell, 2014) Tacit

assumptions behind decisions are rarely exposed or questioned.

Unlike Hollywood movies or music albums, a video game is a complex work that combines the creativity and artistic sense required of an entertainment product with advanced software. (Engström et al., 2018) Prior research has noted the potential for video game project managers to learn from software development best practices. In particular, the complicated software package requires proper project management to ensure the software moves through the design, development, testing and release phases. (Kasurinen, 2016) However, software project management principles are difficult to apply directly because of the creative aspects of the project: the design goals are nebulous and continue to change over the course of the product; the product is built for the abstract purpose of entertaining the end-user, not to fill a well-defined need that can be elicited in advance; the technology is more complicated and continues to evolve; code is rarely reusable or built to last; technical aspects are not typically as important as user experience aspects; and multidisciplinary teams make communication more difficult. (Kasurinen, 2016, Murphy-Hill et al., 2014, Petrillo et al., 2008) Creative project management needs to balance formal project controls to keep the project on track and on budget, with the flexibility for improvisation and iteration needed to maximize the entertainment value for the consumer. (Maier and Branzei, 2014) There are still few defined processes in the video game industry, and game development efficiency suffers as a result. (Musil et al., 2010)

In particular, one area of project management that remains particularly difficult for game developers is defining and managing the project's scope. Petrillo et al. (2008) even attribute a failure to clearly establish the project scope as the most significant project management failure in video game development because changing or emergent requirements force serious reworking of the systems as they are being built. Games contain large amounts of content, in terms of audiovisual assets, to produce and manage. (Murphy-Hill et al., 2014) Scope issues appear in the majority of video game post-mortems; for example, Shirinian (2011) found 71% of the post-mortems analyzed mention the need to cut scope partway through the project in order to complete it on time. Rescoping is expensive and a source of waste – time and resources spent developing aspects of a project that get cut could have been spent on aspects that were not cut, improving the quality. (Wiegers, 1999) Product scope in the context of video games includes content scope, or the amount of the game, and functional scope, the complexity of the game. Both are critical factors in the management of video game projects. An analysis of a content scope decision, the amount of "main path", "single-player" content to provide will be conducted in Chapter 7, and an analysis of one

functional scope decision, the inclusion of a "multiplayer" game feature, will be conducted in Chapter 8.

2.5 Video Game Organizational Learning

One issue preventing the video game industry from moving forward is that it lacks formal systematic methods for learning from projects. In the video game industry, as with other creative industries, the vague requirements they are trying to fulfill prevent many from taking a strategic approach to product development. As Bilton (2007) explains, the result is that decisions are made based on implicit values rather than explicit strategies, which would be open to debate and verification. Bilton also warned that these implicit values are dangerous because they can be used to "impose consensus" or "reinforce unquestioned habits of thought" and, in the extreme, lead to a "dictatorial" approach to management. (Bilton, 2007, p. 103) Jasper (2010) warned that this unwarranted overconfidence is a source of "creativity's dark side". Such an approach is not open to questioning, which means it is not open to being changed.

The knowledge management literature is filled with warnings regarding the danger of overconfidence and existing knowledge as a barrier to innovation or learning – "competence traps", "structural inertia", "the curse of knowledge", "core rigidities", "false knowing", "complacency", "defensive routines", and the "tyranny of the will" all point to the dangers of relying too heavily on unverifiable tacit knowledge, whether or not it has served an organization in the past. (Argyris, 1999, Camerer et al., 1989, Carlile, 2004, Hannan and Freeman, 1984, Leonard-Barton, 1995, Leonard, 2011, Levinthal and March, 1993, Levitt and March, 1988) Decisions and conclusions must be made falsifiable, like good scientific theories, in order to learn from them. (Argyris, 1999, pp. 134-135) Even if there is failure, it is important not to repeat the same mistakes again, but to "fail forward." (Leonard and Swap, 2011)

This is crucial to the creative industries, where every project is an experiment testing an ever-changing market. (Lorenzen and Frederiksen, 2005) The rapid pace of change in the video game industry soon renders existing knowledge irrelevant, (Parkin, 2018) and turbulence in any industry makes learning from experience difficult. (March, 1991) The high rates of turnover and diversity issues mentioned in Section 2.3 also contribute to the difficulty of accruing the knowledge necessary to avoid making the same mistakes; in addition, the high turnover of entire organizations makes it difficult for the industry as a whole to mature. (Peltoniemi, 2009b) An analysis of publicly available post-mortem reports for game development projects suggest the same problems continue to exist despite a long-standing recognition of the issues. (Flood,

2003)

Formal mechanisms for storing and updating the knowledge accrued through individual projects are required to stimulate organizational learning. As Garvin (1993) put it, "Companies must review their successes and failures, assess them systematically, and record the lessons in a form that employees find open and accessible." Chapter 4 builds on the research from prior chapters to present an economics-based business management approach, where decisions based on tacit assumptions can be questioned, verified through a knowledge discovery in database (KDD) approach, and updated, resulting in a learning cycle that can spur organizational learning even in a creative industry, where most of the value is created through the tacit knowledge of its workers, such as video game development.

2.6 Issue Summary

Video game projects are growing more expensive, which increases the risks associated with failure. Businesses must recognize where they are in relation to the competition in the larger market and make strategic decisions on where they want to be in that market. This includes a strategic decision on how they wish to balance their exploration and exploitation activities; a strategic decision on the diversity of knowledge sources they want staffing their projects; and a strategic decision not only on cost and time, but on the scope of their projects. Only when strategic decisions are made and goals are set can those goals be measured and actions adjusted based on the results – in other words, strategic learning is essential for organizational learning in a rapidly changing market, where knowledge is soon rendered outdated making learning critical to survival.

3. Literature Review

This chapter presents the existing creative industry, project and software management, knowledge management, and consumer value literature relevant to this research.

First, it is important to understand the cultural or creative industries because, while they can serve as a guide for innovation practices in other industries, there are important characteristics that make them unique – particularly with regards to the difficult-to-define value proposition being made to customers and consumers.

Video game development is a blend of creativity and software engineering, so understanding project management and management of software development projects is also critical for improving video game business management. An understanding of how scope is managed within the project management field as well as best practices is essential to explaining why scope must be controlled in video game development.

The knowledge management literature provides an important foundation for the need to verify and update existing knowledge – the fundamental intent behind presenting an economic approach to video game business management.

Finally, defining what provides value to the consumer is essential for quantifying and evaluating whether the assumptions behind decisions need to be re-examined.

3.1 Cultural and Creative Industries

The video game industry is one of the cultural or creative industries. In these industries, the primary product is information-based, and in the video game industry's case, entertainment-based. Creative industries deal in "symbolic goods" (Bourdieu, 1985), with their value subjectively defined by the interpreted value they provide to their consumers. (Bilton, 2007, p. xvii) They differ from other industries in that the most important "ingredients" of the product that provide value to consumers are intangible, or "symbolic." (Bilton, 2017)

A distinction is made between "cultural industries" as producing copyrightable products and "creative industries" producing products that have value in use. (Hesmondhalgh and Pratt, 2005) For the purposes of this research, the video game industry is both a cultural industry and a creative industry. However, because the software development side of video game development is considered in the course of this research, I will default to the broader term, creative industry, except in cases where the symbolic "copyrightable" nature of video games is more pertinent to the discussion. The

creative industries are important to study because traditional industries are beginning to resemble them, with growing demands for innovation and serving a fragmented customer base. (Lash and Urry, 1994)

One myth regarding work in the creative industries is that creatives work best when freed from constraints; however, setting constraints needs to be seen as part of the creative process because they provide important boundaries for the creative process. (Bilton, 2007, p. xxi) Rather than shielding creatives from market realities, "strategic targets" can help them focus their creativity; "managers and creatives need to negotiate the boundaries and parameters around the problem together." (Bilton, 2007, pp. 86-87)

There is a growing awareness of the negative aspects of the creative industries in research. To avoid the risks inherent to producing profit in an industry where "nobody knows" (Caves, 2000) what will succeed, organizations and projects are structured so that much of the burden of failure is placed on the employees. (Mills and Horton, 2016, p. 124) Creative jobs may offer more freedom and flexibility than traditional industrial jobs, but the downside is that they are more insecure and pay less. (Oakley, 2009) Work is usually short-term and irregular, and there is almost no job protection. (Hesmondhalgh, 2008) Workers are often forced to be available at any time and are often forced to relocate to find their next job. (Ruth Eikhof and Warhurst, 2013) DeFillippi and Arthur (1994) defined "boundaryless careers" as careers that are not confined within the boundary of one employer. In the creative industries, it is rare to remain with one employer for long. These boundaryless careers place high demands on their workers, (Jones, 1996) and their flexible, tenuous nature means that employees feel pressured to always be working and that their participation in the creative industries can have "destructive" effects on their other identities, which they have to sacrifice to remain in competition for work. (Prichard, 2002) Even outside of work, creative workers are forced to socialize in order to raise their social capital and find work (Oakley, 2009) – something that is particularly difficult for workers with families, resulting in exits from the industry, and women, leading to some of the gender disparity issues covered in Chapter 6, or ethnic minorities. (McRobbie, 2002) For the most part, the creative industries favor young men in the ethnic majority. (Deuze, 2016) "Projectification" and the tenuous nature of employment have been found to be detrimental to creativity – by nature, the resource most required of employees in the creative industries. (Lundin and Norbäck, 2016)

Although there are both scholars who support the positive aspects of the new creative career and those who are critical, the stance taken in this research is neutral. There are pros and cons to knowledge management in the context of flexible,

boundaryless careers. Project networks and recombination of actors provide new sources of innovation for organizations, while the loss of tacit knowledge is likely to be harmful in such a complex environment.

3.2 Project and Software Management

This research extends the project and software management literature by demonstrating how the fundamentals can be applied to the unique case of video game development, where creativity is as much a contributor to project success as successful software development.

Kerzner (2006, p. 4) provides a useful definition of project management as "the planning, organizing, directing, and controlling of company resources for a relatively short-term objective that has been established to complete specific goals and objectives." In the video game case, game development projects are typically a few years in duration with budgets for hit "AAA" games in the tens of millions of dollars. Projects are the preferred method of production in creative industries because they allow for a limited, focused concentration of resources to a creative endeavor. (Ruth Eikhof and Warhurst, 2013) As Lorenzen and Frederiksen (2005) noted for the music industry, projects are a form of experimentation – if the project succeeds, further development continues, and if the project fails, further support is canceled.

Software project management is difficult, even outside the realm of game design. As far back as Brooks (1975), engineers have known that estimating projects is one of the most difficult tasks to get right. Most software projects fail to complete on time, larger projects are more likely to slip, and complexity underestimation is a core problem. (Kemerer and Patrick, 1993) Jenkins et al. (1984) discovered that only 9% of the projects they observed were finished with the scheduled manpower effort and the average additional effort required was 36%. Of the projects DeMarco and Lister (1987) surveyed, 15% were so late they were cancelled and 25% of large projects were cancelled. Several of the core risks inherent to software development include: scheduling flaws, requirement inflation, exiting staff, specification break downs, and lowered productivity. (DeMarco and Lister, 2003)

The research agrees that the size of projects can lead to problems. One of Boehm and Papaccio's (1988) four strategies for improving software productivity was, "writing less code." When Vosburgh et al. (1984) analyzed 44 programming projects, they noted that productivity falls as the number of lines of code involved increased, in addition to noting that both accurate and stable requirements and specifications could improve productivity. Charette (2005) provided examples of how software project failures have

cost considerable amounts of money. He listed many of the problems that cause projects to fail, noting that it is often multiple, intertwined factors at work. He also noted that larger projects carry more complexity, which increases the likelihood of errors. Curtis et al. (1988) described three issues that occur in large software development projects: thin spread of domain knowledge, fluctuating requirements, and communication breakdowns. They mentioned several problems, including the hidden cost of feature creep and the difficulty for stakeholders to see the cost or complexity of the systems they require. Reducing content and functional scope, and thus complexity, to the minimum required is critical for project success.

Under the *Capability Maturity Model* (Figure 3-1), as software management matures, it goes from the initial chaos to being repeatable, defined, managed, and finally optimized. (Humphrey, 1988) Especially for being manageable, having agreed-upon metrics as to the effectiveness of a development process is what allows this management to occur. To improve software development, an understanding of the current process is required, followed by a vision of the desired process, a list of improvements to be made, a plan to accomplish those improvements, and commitment to executing the plan. The need for more objectivity is summarized by Paulk et al. (1993), "In an immature organization, there is no objective basis for judging product quality or for solving product or process problems. Therefore, product quality is difficult to predict."

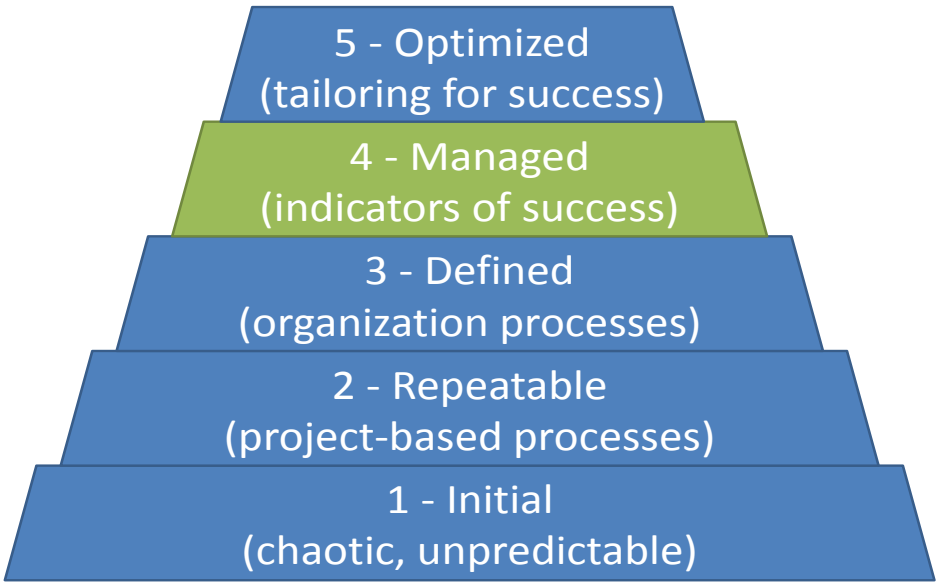

Figure 3-1. The Capability Maturity Model with the "Managed" level highlighted.

(adapted from Humphrey, 1988; Paulk, Curtis, Chrissis & Weber, 1993)

Any project is going to require a balance of quality, time, and costs and software project managers must be aware of each and decide which has the most strategic value for their company. (Yourdon, 1995) Although there is a tendency to strive for large scope and high quality by default, not all software has to possess such ambitions. Yourdon stressed that accepting "good enough" as one possible outcome could lead to "a more rational way of negotiating with our customers and managers on what constitutes success." He also stated that, "It is the customer who decides what the proper balance is," and that balance might change over time, which is why project managers may need to readjust priorities after the project is underway. Project managers must, therefore, find ways to understand what their customers value.

The role of a product manager, like a producer in video game development, is deciding what content to deliver in which timeframe to what market at what prices and cost. (Ebert, 2007) However, determining the value or cost of individual requirements in software can be very difficult and complicated. (van den Akker et al., 2008) Product releases often fail because they misinterpret customer needs. Ebert also stated that any incoming requirement should be reviewed for cost versus value added. Determining which efforts lead to value is important, for as much as 25% of software activities may not contribute to value and 50% of developer time may be wasted, with much of this waste due to overspecification and overdesign. (Coman and Ronen, 2010, Pass and Ronen, 2014, Ronen and Pass, 2008)

Boehm and Papaccio (1988) concluded, "understanding and controlling software costs is extremely important, not just from an economic standpoint, but also in terms of our future quality of life," and "the better we are able to understand software costs and qualities, the better we are able to control them – and vice versa." This philosophy is present in Boehm's (1984) Software Engineering Economics.

Project and organizational management in the creative industries have largely gone neglected and have received limited attention from researchers. (Lampel et al., 2000) One problem is that management in creative organizations is not often considered central to business success or a core competency. (Jeffcutt and Pratt, 2002) Most of the "managers" in a creative enterprise are drawn from successful content producers and have had no formal management training before taking on the role. (Deuze, 2016) In place of any formal training, they are often forced to learn while they go, and, as Armstrong and Page (2015) put it, those in senior roles are in a similar situation, resulting in a situation where they are the "blind leading the blind." With few creative

employees having formal management or project management training, they are likely to focus on the creative aspects of their position. However, leaving creative projects uncontrolled is dangerous because controls are a key to project success. (Maier and Branzei, 2014) The need to be an effective project manager cannot be ignored. Lundin and Norbäck (2016, p. 379) insisted that media managers needed to become more "project fluent" given the growing complexity of projects and teams.

Although one approach to balancing the need for management with the need for creativity is to split the two roles, Wilson (2009) made an argument that introducing artificial divisions between those who are creative and not is not a helpful concept, but rather what is important is to focus on the value of the results – a core concept in an economic approach to business decision making. Of course too much control can inhibit the autonomy needed to experiment and be creative, but "too much creativity" and a lack of discipline are as much a problem. (Townley et al., 2009) There is certainly a balance that must be made, but, as Lampel et al. (2000) argued, creative organizations that want to survive "must reconcile the demands of artistic production with those of the marketplace." Bilton and Leary (2002) even went as far as to argue that creativity is not a quality of people but of systems and that proper management can help rather than hurt creative efforts. This research agrees with this viewpoint, and particularly the viewpoint of Peltoniemi (2009a), who argued that "the purpose of control mechanisms, such as budgeting and definition of responsibilities, is to keep people within acceptable alternatives." Controls may not necessarily make a creative project successful, but they can help prevent failure – something that is growing riskier in the current video game industry. Proper management of creative projects prevents wasted resources, which allows those resources to be devoted to creative efforts.

3.3 Knowledge Management and Discovery

Knowledge is accrued as the information from past experience is interpreted and made relevant or actionable for future decision making. (Davenport and Prusak, 2000, p. 7) Organizations capable of learning from and adapting to their environments are effective at "creating, acquiring, and transferring knowledge," and, critical to the arguments of this research, "at modifying its behavior to reflect new knowledge and insights." (Garvin, 1993) In other words, the successful management of knowledge is critical to organization learning and survival in a changing environment. Relevant to video game development, the majority of new product development failures are attributable to a lack of knowledge about the market or about the competition. (Calantone and Cooper, 1979) A firm's innovative capability depends on its ability to

"recognize and assimilate new, external information." (Cohen and Levinthal, 1990)

Creative industries can benefit from a knowledge management approach. Project teams will "be more effective if they work to a brief and if they retain some organizational memory of previous projects." (Bilton, 2007, p. 42) Knowledge management requires management of not only explicit knowledge, but of tacit knowledge. Two important difficulties with experience-based tacit knowledge, beyond the difficulty of expressing it, are that it is based on the limited experience of the holder, and that it is generated through intuition regarding those experiences. The result is that "not all tacit knowing is valuable or even accurate." (Leonard and Sensiper, 1998) In the video game industry, with so many entries and exits, it is clear that some individuals and organizations possess more "valuable" tacit knowledge than others. Popper (1979, p. 167) warned that intuition was fallible and "must be controlled through rational criticism" because "control through criticism is the rational aspect of the growth of knowledge and of our personal growth." One of the primary risks of relying entirely on tacit knowledge is that the "ambiguity" that surrounds it makes it difficult to challenge and change even if it is mistaken. (Levitt and March, 1988)

In particular, if a systematic learning process is not in place, where a hypothesis is explicitly stated and tested, "hindsight judgment" of business results based on poor decisions can be explained or reinterpreted to seem correct. (Levitt and March, 1988) People prefer to hold on to their existing knowledge schemas because they favor "order, consistency, and stability" and this need is so powerful that it biases the interpretation of newly acquired information to support those schemas. (Choo, 2006, p. 119) Confronted with data that conflicts with tacitly held knowledge, knowledge holders resort to "self-sealing logics" by inventing explanations that are "plausible, persistent, and sealed off from refutation." (Weick, 1995, p. 84) All knowledge contains elements of judgments, values, and beliefs of the holder. (Davenport and Prusak, 2000, p. 10) These beliefs hold influence even at the level of the organization, where information that conflicts with organizational beliefs can be reinterpreted to avoid confrontation in the name of "protecting the organization". (Choo, 2006, p. 50)

Just as individuals differ from each other in the way they perceive and react to their environment, organizations essentially differ in the value they offer by their knowledge frameworks and how they interpret the same realities in different ways from their competitors. (Nonaka et al., 2008, p. 9) The traditionally espoused one-way path from data to information to knowledge is flawed in this respect, because prior knowledge influences the perception of information. (Tuomi, 1999) In the end, the lessons learned from interactions in the marketplace are less influenced by the actual

realities of the marketplace but more by the interpretive framework applied to those events. (Levitt and March, 1988) As Polanyi (2012, p. 151) warned, these interpretive frameworks are difficult to modify, because they can absorb most of the evidence and are coherent enough to justify the ignoring of "facts which it cannot interpret." Frameworks, paradigms, or "mental models", affect the perception of reality in organizations as they do in people. (Bazerman, 1984, Johnson-Laird, 1983, Tversky and Kahneman, 1979) Knowledge must be "constantly questioned and updated to reflect an ever-changing reality." (Fahey and Prusak, 1998)

The role of tacit knowledge in business organizations was brought to light by Nonaka (1991), who applied Polanyi's philosophical concept of "tacit knowledge" to an organizational context and introduced the *SECI model*, which models the flow of knowledge that leads to its creation in organizations. Nonaka observed that knowledge flows through the four steps that give the SECI model its name: "socialization", "externalization", "combination", and "internalization". Making tacit knowledge explicit is important in the cycle, because reconfiguring or combining existing explicit information can lead to new knowledge. (Nonaka, 1994)

There is some controversy surrounding the way Polanyi's "tacit knowledge" was originally used by Nonaka and others as a substitute term for "implicit knowledge" in contrast to "explicit knowledge" (see Wilson (2002) and Tsoukas (2003)); however, throughout this dissertation, I deliberately use the term "tacit knowledge" to represent knowledge that has accrued in an individual or an organization based on experience. Although in most cases, this research argues the need to make tacit knowledge explicit and testable, the belief that such knowledge is expressible if the correct systems are in place means that "tacit knowledge" is not used in contrast to "explicit knowledge," but leaves open the possibility for the same need to revise explicitly presented tacit knowledge, for example. Although it would be equally appropriate to use the more general term "knowledge", the "tacitly held" nature of knowledge is important to remember and is the reason the specific term will be used.

Tacit knowledge is particularly relevant to creative industries, where creativity, talent, and innovation are so important. In project-based organizations, such as the video game industry, their temporary nature makes it difficult to take the lessons learned on the project and apply them to the wider organization. (Landaeta, 2008) Media workers themselves even find it difficult to explain the reasons behind their talent. (Deuze, 2016) However, in industries where consumer values change, these talents are "amorphous resources" that can "lose their value for reasons that are not entirely understood." (Lampel et al., 2006) The result is that, despite the economic value

of creative industries such as the video game industry, the "creative process" remains "unruly and poorly understood." (Jeffcutt and Pratt, 2002)

Successful learning organizations are adept at five processes: "systematic problem solving, experimentation with new approaches, learning from their own experience and past history, learning from the experiences and best practices of others, and transferring knowledge quickly and efficiently throughout the organization." (Garvin, 1993) Pfeffer and Sutton (2006) recommended an "evidence-based management" approach, where claims are asked to be supported by data, the logic behind decisions parsed for faulty reasoning, and experiment-based continuous learning is reinforced.

"Learning from the experiences and best practices of others" is important for scaling potential learning from that which is possible within a single organization and a few projects to that of all of the projects in other organizations in the same industry. One method for updating knowledge so that it remains relevant to overall trends in an industry is to rely on data about the wider industry. Recently, knowledge discovery in database (KDD) techniques, particularly data mining, have been seen as an important tool for improving business decisions.

Data mining (DM) is one of the steps in the KDD process, which is used to discover information hidden within large amounts of data. (Fayyad et al., 1996a) Fayyad et al. (1996b) described the data mining step as "searching for patterns of interest" in data, which can then be interpreted, followed by "acting on the discovered knowledge." Specifically, data mining "is an interdisciplinary field that combines artificial intelligence, computer science, machine learning, database management, data visualization, mathematic algorithms, and statistics" and is "a technology for knowledge discovery in databases" that provides "methodologies for decision-making, problem solving, analysis, planning, diagnosis, detection, integration, prevention, learning, and innovation." (Liao, 2003)

Davenport (2006) argued that organizations must begin to compete on analytics because analytics can help "wring every last drop of value" from an organization's business processes. KDD techniques like data mining can be used to feed data into business intelligence (BI) or decision support systems (DSS). Although DSS have been around for decades, the introduction of "data-driven" elements have led to the emerging of "business intelligence (BI)" systems. BI systems are DSS designed to provide decision makers in business organizations with the information they need to make better decisions and have been shown to provide both operational and strategic value to organizations. (Fink et al., 2017) Matei (2010) stressed that, "Getting high quality data

is no longer a profit and loss issue, but a surviving on the market issue, a matter of success or failure," and that BI systems "allow rapid reactions to the business environment changes" that occur around an organization.

One important caveat regarding any decision support system is that it should not replace the human decision maker. Davenport et al. (2001) found three critical success factors necessary for turning data into knowledge: context, transformation, and outcomes, but warned that that companies need to change culture if they want to incorporate data-based decision making into their organization, as often the decision-making process is a black box, with decision makers making their decisions without data or knowledge to support them. They noted that "analytic tools such as data mining are most effective when they are guided by human insight." "Controlling the work process means control of the work, and not control of the worker." (Drucker, 1974, p. 217) Data is not about forcing design by committee, but about providing more information for intelligent decision making. (Lewis-Evans, 2012) The user of any support system should always have sovereignty, and one decision support system or model can never be enough to answer a complicated problem, requiring an integration of methods. (Wierzbicki and Nakamori, 2005)

3.4 Consumer Value

The managerial economic perspective applied to video game business management presented in this research builds on the foundations of KDD and the use of BI in decision-making but applies it in a way that is appropriate to a creative industry where tacit knowledge is the primary source of value, problems are complex, and goals and definitions of value are vague. One way this is made possible is by focusing on business management and the value provided by entertainment products to the end consumer rather than on abstract concepts such as the inherent quality of artistic expression.

Woodruff (1997) made clear that quality is not enough to provide a competitive advantage; instead, it is delivering what the customer values that provides the advantage. For an organization to compete in delivering value, they must "learn extensively about their markets and target customers." Being an organization that focuses on delivering customer value requires consideration of four questions: "1) What exactly do customers value? 2) Of all things customers value, on which ones should we focus to achieve advantage? 3) How well do customers think we deliver that value? 4) How will customers value change in the future?"

Vargo and Lusch (2004) proposed that value can only be decided by the customer

and that value is only created when the beneficiary experiences the results of service. Thus, all value must be considered in context, and "producers" do not actually produce value, they can only propose value. Value is, in fact, co-created by the producer, who makes a value proposition, and the customer, who decides the value by accepting or declining the proposition. (Lusch and Vargo, 2006) Nonaka et al. (2008, p. 25) discussed how a SECI process of knowledge creation is involved in the validation of a value proposition in the market, and how "knowledge is created anew in the synthesis of views from the market." Drucker (1993, p. 83) argued that the most important question for any business could be, "What is value to the customer?" In the end, the customer is the only one who can decide value – a concept that provides the foundation for a managerial economics perspective in the creative industries.

The stance taken by the economic approach perspective employed in my research is that the video game market contains the information essential for falsifying or validating the tacit assumptions behind management decisions, which is what allows KDD techniques to benefit organizational learning in a creative industry.

3.5 Position of this Research

This research addresses the often cited difficulties with managing organizations and projects in the creative industries by focusing on how a learning process that incorporates external knowledge can be used to question and validate decision making. The focus of this research, the video game industry, is in particular need of decision validation because it is rapidly growing and can be considered more complex than many other creative industries because it is a complicated multidisciplinary effort requiring the efforts of software engineers, artists, sound designers, interaction designers, and a wide range of support staff. Video game development is on one hand a software development project, but on the other hand an artistic work, requiring decision makers to be versed in the best practices of both.

As prior research has warned, these decision makers are limited by the tacit knowledge contained in their prior experience. This research takes the position argued by the organizational learning researchers cited that decisions must be made explicit and verified if learning is to take place.

Video game development has to simultaneously balance both artistic and business objectives. As the goal of this research is to improve business decision processes, it is situated against the backdrop of research into what constitutes value for consumers. Without this base, a rational decision process would be difficult to implement because, if "value" is defined by artistic considerations, then everything

becomes subjective and one tacit assumption is as good as another. However, the reality is that some video game business succeed, and others fail – going out of business in many cases. Optimization of business decision processes must focus on learning how better to succeed as a "business" providing value to its consumers in return for the economic resources it needs to continue operation.

The unique position of this research is that it demonstrates how a KDD approach that analyzes data external to an organization can be incorporated into the learning process in a creative industry – a video game organization. Although the research focuses on the video game industry for the reasons stated above, a similar approach to the one this dissertation describes could be applied to the decision-making approach in any creative industry, which relies mostly on experience-based tacit knowledge to generate value.

4. Video Game Business Management Economics

In Chapter 4, I note the limitations of tacit knowledge and propose a new process for validating tacit knowledge that has accumulated within decision makers in the video game industry with potential application to other cultural and creative industries. The proposed process is an answer to the question:

- How can an economic perspective that views decision optimization in terms of making the best use of limited organizational resources allow for the use of data from the wider industry to question assumptions and improve video game business management decision processes?

This approach will be employed in case examples described in Chapters 5, 6, 7, and 8 covering a range of decisions, such as those made for portfolio strategies, human resources, and projects, made by video game development business and project owners. Within the quantitative research conducted in each of these chapters, insight is provided into the results of the decision-making process of video game organizations. Many of these decisions are made based on the experience-based tacit knowledge of the decision-makers; however, there are limits to the amount of experience an individual can draw on as well as traps to relying on tacit knowledge. In a creative industry, such as video game development, reliance on the tacit knowledge of employees carries unique risks that need to be balanced by a rational decision-making process.

This chapter extends the traditional double-loop learning cycle to include locating decisions based on tacit assumptions and falsifying or validating them through the introduction of data external to an organization obtained from knowledge discovery in database (KDD) techniques. By doing so, it presents an approach to improving decision-making in video game organizations, made possible by considering the results of decisions on how best to utilize limited resources through a managerial economics perspective focusing on the value they provide to a business.

4.1 Economics and Business Management

There are many definitions of economics, but one of the first accepted definitions came from Alfred Marshall, who called it both a “study of wealth” and a “study of man”. (Marshall, 1920, p. 1) However, commonly accepted modern definitions are derived from

the Robbins (1932, p. 15) definition of economics as "the science which studies human behaviour as a relationship between ends and scarce means which have alternative uses," which led to future definitions that focus on the rational decision-making aspects (Backhouse and Medema, 2009).

Managerial economics, introduced by Dean (1951), combines economics with decision making in a business context. It proposes the use of "the products (and more importantly the methodology) of economic science to make better decisions." (Hill, 1989, p. 1) Managerial economics is the application of economic theory and quantitative methods (mathematics and statistics) to the managerial decision-making process." (Webster, 2003, p. 5)

Within managerial economics, limited resources are a critical factor in decision-making because there are multiple ways to produce the required outputs, but some are more efficient than others. Essentially, managerial economics is concerned with optimization of the decision-making process in a business context. Managerial economics is also concerned with the concepts of risk and uncertainty, which arise from imperfect information. (Webster, 2003, p. 621) These are critical concepts in decision-making within creative industries, such as video game development, because "nobody knows" what will succeed in the market. (Caves, 2000, De Vany and Walls, 1999) Uncertainty arises when there is no knowledge regarding the probabilities of different outcomes, but uncertainty is transformed to risk "whenever the decision maker is able to use personal knowledge, intuition, and experience to assign subjective probabilities to outcomes." (Webster, 2003, p. 656) Once uncertainty is transformed into risk, the decision-making process can be optimized on a rational basis. Important is the knowledge held by the decision-maker, who needs methods for discovering the subjective probabilities of different possible outcomes. However, this knowledge can be imperfect.

An economics approach has applications for any decisions made within the management of a firm, which includes strategic innovation management decisions, such as the decision to explore new intellectual property (IP) or exploit existing properties as in Chapter 5; human resource or "talent management" decisions, such as the decision to improve gender diversity in critical roles to address the imbalances shown in Chapter 6; and project management decisions, such as the decision to optimize product content and functional scope described in Chapters 7 and 8.

One prior application of managerial economics to decision-making within project management was in software engineering. In "Software Engineering Economics", Boehm (1984) described economics as the "study of how people make decisions in

resource-limited situations." Boehm noted the importance of data in verifying predictions, which allow them to be calibrated to better reflect reality in the future. An economic perspective allows project and organization owners to shift from a "seat-of-the-pants" approach to decision-making to a rational approach. (Boehm, 1984) Boehm also argued that one of the benefits of an economic approach is that it provides a "clear and consistent universe of discourse." Although there are limits to the amount of information that can be applied to a decision, resulting in a "bounded rationality" (Simon, 1957, Simon, 1972), having a rational decision-making process allows for that process to be questioned and better tuned to reality. Focusing on the business value of tacitly held knowledge in video game or other profit-driven creative industry organizations allows for the employment of a managerial economics perspective, with its focus on using limited resources to maximize business value, which allows the products and methodology of economics to be applied to optimize decision-making in those organizations.

4.2 Traps of Relying on Tacit Knowledge in Decision-Making

The dangers of self-sealing logics surrounding tacit knowledge have been made clear in the research cited in Section 3.3. Even when confronted by data regarding the wider industry through the techniques demonstrated in Chapters 5 through 8, there is still the danger that it will be misinterpreted to support existing knowledge frameworks. Argyris (1999) described the "defensive reasoning" that exists in individuals and organizations, preventing learning, and recommends "productive reasoning" that subjects tacit knowledge to open testing. Argyris (2000, pp. 194-195) argued that "sound choices" do not rely on intuition alone; although opinions can be useful as they are based on tacit knowledge accumulated from experience, their logic needs to be made explicit and testable. Leonard and Swap (2005) warned that expert experience is limited because experts can fall prey to "false knowing," which includes "ignorance," "overconfidence," and, relevant to the arguments in this chapter, "failure to examine assumptions."

The risk of KDD techniques supporting existing knowledge frameworks needs to be addressed. One of the primary risks of relying entirely on tacit knowledge is that the "ambiguity" that surrounds it makes it difficult to challenge and change even if it is mistaken. Levitt and March (1988) warned that, without a systematic learning process where a hypothesis is explicitly stated in advance and tested, the results of a business decision process can be reinterpreted to reinforce the existing knowledge framework.

The difficulty with proving the veracity of knowledge was laid out by Popper

(1959), who argued along the lines of David Hume that no amount of evidence can prove a hypothesis; rather, Popper introduced, a hypothesis can be considered scientific if it is falsifiable. (Popper, 1963) In other words, the value of a theory in explaining reality is related to its falsifiability. This is critical for updating knowledge that could explain prior experience but is inferior to alternative ways of thinking. Unlike science, there is a further complication with knowledge in a business setting: "reality" can change – consumer demands, market conditions, and resource availabilities can all vary over time and invalidate prior knowledge. Although an uncomfortable concept, managers must accept that any tacit knowledge they hold could be falsified, and, where possible in a business context, design decision-making processes with the potential to "falsify" it. Just as in science, the goal of organizational learning should be to get closer to the truth by discarding mistaken knowledge and replacing it with knowledge that explains more of the underlying economic reality.

For a business process to avoid the traps of tacit knowledge, it must frame decision-making in a manner that seeks proof the knowledge is mistaken. If the results do not disconfirm the hypothesis behind the decision, then it could be acceptable to continue relying on it until disproved in the future. To update tacit knowledge, decision assumptions must be stated in advance, the conditions for falsifying those assumptions must be decided, and then the decision results must be compared against the assumptions. In traditional single-loop learning, actions are executed and the results guide further action. (Figure 4-1)

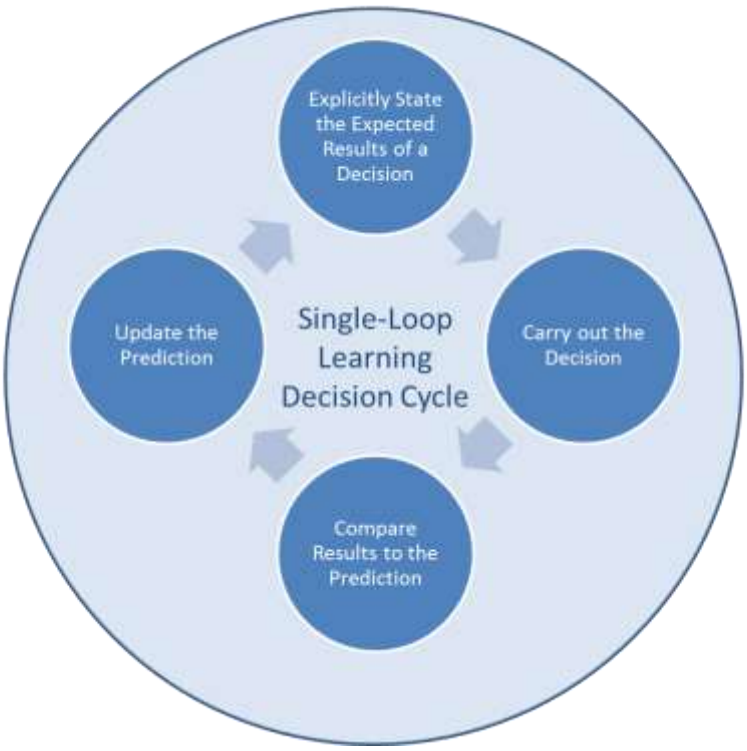

Figure 4-1. A traditional single-loop learning cycle, such as a Plan-Do-Check-Act (PDCA) decision cycle for improving future decisions.

The drawback to this cycle is that the assumptions driving the decision are unquestioned, and therefore not self-corrective, instead requiring an internal or external crisis or a change in the organizational power structure for them to come into question. (Argyris, 1977)

One model of organizational learning that attempts to address the traps of relying on tacit knowledge and correcting inaccurate assumptions in the decision-making process is double-loop learning. (Figure 4-2)

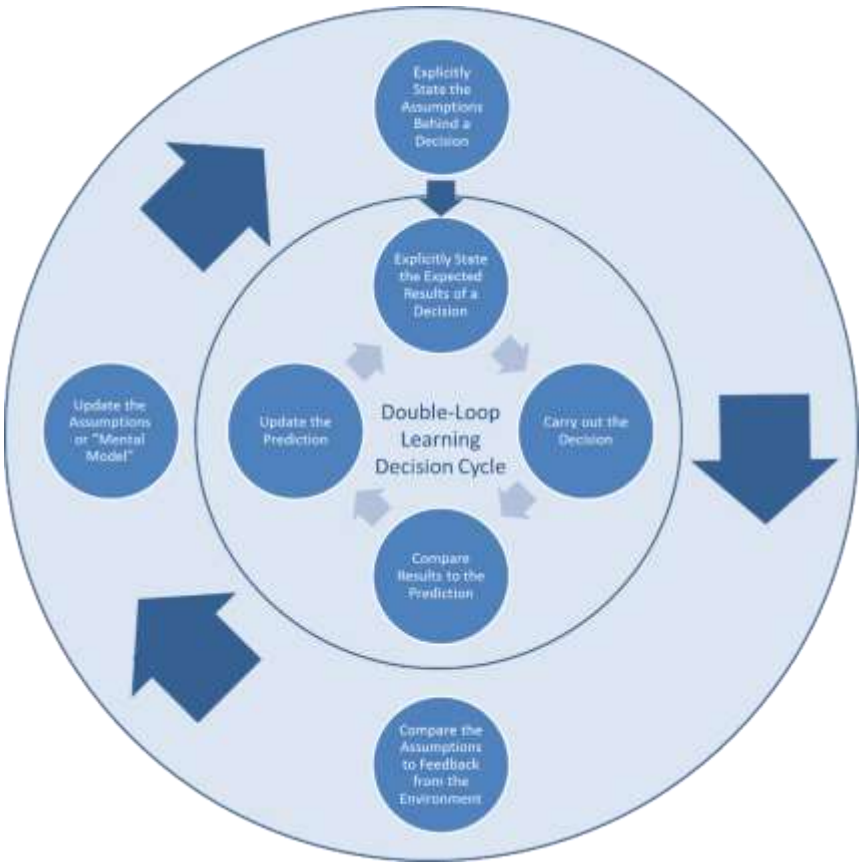

Figure 4-2. A double-loop learning cycle, which extends the single-loop learning cycle by stating assumptions, comparing those assumptions to information feedback, and updating the mental model creating the assumptions as a result so that better decisions are made in the next cycle.

Double-loop learning acknowledges that the way decision-makers define and solve problems "can be a source of problems in its own right." (Argyris, 1991) Double-loop learning requires "reliable information" and "monitoring continually the effectiveness of one's decisions", which requires a constant questioning of the assumptions behind decision-making; however, there are two important flaws in the double-loop learning cycle – confirmation bias and the location of assumptions – that make double-loop learning difficult to implement in a creative industry such as video game development. The reasons these flaws are important to address when attempting to introduce a double-loop learning cycle to a creative industry and how these flaws can be corrected are addressed in Section 4.3.

4.3 The Limits of Tacit Knowledge in Video Game Organizations

On one hand, the validity of tacit knowledge behind decision-making in a creative industry, such as video game development, can be considered subjective as the resulting products are "artistic" – meaning the value they hold is open to interpretation. If the goals of video game development were purely artistic, then any assumptions on the part of decision makers would be impossible to falsify or validate as all assumptions could be equally valid. However, in the context of a business organization, profit is a motive, economic principles apply, and the validity of the tacit knowledge used as an input to decisions becomes measurable. With a managerial economics perspective, the assumptions behind one decision on how best to utilize limited resources are better than another if they result in more value to the organization. A focus on business value is what allows economics to inform the creative process.

Determining what provides value to a consumer is difficult in a creative industry where the vague concept of "entertainment" provides the source of value and the definition of entertainment is constantly changing. In prior research, I addressed some of the difficulties for game designers trying to determine what entertains their players by proposing a technique that overcomes the limitations of lab-based user testing by observing players over livestreams in a more natural playing environment. (Bailey and Ito, 2017a, Bailey and Ito, 2017b) This research was important, because the entertainment value generated for a player becomes more difficult to measure the further they are from the context of their natural "consumption environment." Consumers decide the value provided by a creative product, like a video game, so, while it is important to have theories regarding what consumers value when designing a game, it is important to find ways to test those theories with the consumer. Techniques such as the one proposed could help mitigate some of the difficulty testing value before a video game product is released. The other side of verifying value propositions and updating tacit assumptions is to test the results of those propositions in the wider industry with KDD techniques.

The impact of "boundaryless careers" (DeFillippi and Arthur, 1994) on both tacit knowledge and the decision-making process must also be considered. Although employers of creative industry workers benefit from being able to scale their projects in a flexible manner, they cannot rely on employees to store the organization's knowledge. Knowledge accumulated by employees is no longer bound to one employer, and in fact,

employees are best served by focusing on their own career portfolios given they may soon need to be looking for a different job. In this environment, it is unreasonable to assume that creative industry workers will put the needs of the organization first. (Jones, 1996) Deuze (2016, p. 332) noted that creative professionals, "tend to identify first and foremost with how they see themselves as a practitioner," which also has implications for decision-making. A creative professional is motivated to favor decisions that improve the critical reception of his or her work. This has dire implications for the business side of a creative industry like video games, which relies so heavily on the tacit knowledge of its employees for value production and decision-making. A long career within one firm is no longer the norm, and in many ways, other industries are coming to resemble the creative industries – no longer able to equate their core competencies with the individual competencies of their employees.

Another issue with video games is that, as software projects, they have "ballooned in complexity." (Blow, 2004) Team sizes have grown, and it requires years to develop a hit "AAA" game. Even veteran directors and producers can only accumulate experience from a limited number of products, and given the increasing reliance on intellectual property "exploitation" that will be demonstrated in Chapter 5, the products they are likely to work on are similar to prior ones. This experience limitation means that the tacit knowledge acquired from that experience is also limited.

Despite this limitation, organizations in the creative industries often subscribe to the "myth of genius" (Weisberg, 1993) and take a hands-off approach to management. In many cases, they place their trust in "convenient" creative brands and assume that previously successful creators will be successful again. (Bilton, 2007, pp. 16-17) However, this may not be the case. Simonton (2000) found that the ratio of "hits" to "attempts" does not increase over the course of a creative career, but fluctuates. Past creative performance is not necessarily a good predictor of future performance, and creators with prior success are less likely to abandon existing knowledge. (Cattani and Ferriani, 2008) Research by Katz and Allen (1982) into research and development processes demonstrated a different problem with prior success; groups grow complacent with repeated success and the communication rate with external sources of information falls. Such a situation could increase rather than reduce risk in a rapidly changing environment. If an organization continues without processes to encourage the incorporation of external information, there are fewer opportunities to validate or correct the tacit knowledge that accumulates with experience.

In cases where a creator's decision process is left unquestioned, the problem can grow. Tschang's (2010) qualitative research into game development organizations

revealed that when creators are given strong top-down control over their teams, they can fail to "rein in his or her creativity" and "acknowledge problems in the product." In any organization, leaders with higher status can claim stronger value in their beliefs. (Choo, 2006, p. 135) Ackoff (1999, p. 165) made an argument that, as leaders climb in status, the likelihood of mistake concealment rises and the likelihood of learning falls.

Even in creative industries where "nobody knows" (Caves, 2000) what will succeed, leaders with past success underestimate the role of luck and can fall prey to the illusion that they will be able to predict and control future successful projects. (De Vany and Walls, 1999) In the creative industries, so many factors influence the results of business decisions that, even when assumptions are confirmed, there is no guarantee that the initial assumptions are indeed valid. The video game market is also rapidly evolving, quickly invalidating knowledge that may have proven useful in the past. (Parkin, 2018) Although experience and tacit knowledge can serve as a starting point for decision-making, and serve as the primary source of value in creative industries like video game development, organizations must recognize their limitations and implement processes to validate or update that knowledge to better understand the value they are providing to consumers.

Over time, through their experience, video game developers accumulate tacit knowledge, some of which forms the basis for useful assumptions and some of which does not. Verifying and updating assumptions through a double-loop learning cycle is one way to renew the body of useful knowledge available to decision makers based on feedback from the environment. However, double-loop learning contains flaws that prevent its effectiveness in correcting mistaken assumptions. One problem is the problem of confirmation bias – just because feedback appears to confirm an assumption does not necessarily mean the assumption is justified, the other is knowing when or what assumptions are made in the decision process – "individuals must interpret the mismatch" between assumptions and results "as needing examination." (Blackman et al., 2004) These are difficult flaws in the double-loop learning process to overcome, particularly in the creative industries where tacit knowledge is responsible for the majority of value creation. However, Popper (1963) provides a way to address the flaw of confirmation bias, by turning the assumption around and seeking evidence to "falsify" it rather than confirm it. While there is no way to ever "prove" an assumption is correct, such a methodology at least allows assumptions that are false to be questioned and updated to reflect the underlying reality. In the creative industries, consumer tastes and markets change so rapidly that this underlying reality is too fluid to ever assume that one has "confirmed" the tacit knowledge one holds regarding the market realities.

For this reason, seeking "falsification" is a critical adjustment that needs to be made to the traditional double-loop learning model for it to be useful in the creative industries. The other flaw is being able to identify what assumptions are made in the decision process.

Although it can be possible for the decision-maker themselves to recognize their own assumptions, it can be difficult as the industrial and organizational cultures they are a part of provide a framework for interpreting the world. For an organization seeking to question more of the assumptions behind decisions, it can be helpful to enlist an observer external to the project team, business unit, or organization who is less likely to be influenced by the culture generating the framework and unquestioned assumptions. In the creative industries, such as video game development, most knowledge is tacit and based on the prior experience of the decision maker, which implies it is limited to that experience. This is particularly concerning if, as Chapter 6 discovers, decision makers in the video game industry do not come from diverse backgrounds. If everyone's knowledge derives from similar experiences, it fosters the potential for "groupthink." Janis (1972) found that people working on highly cohesive groups tend to seek concurrence at the expense of processing new information – the more cohesive the group, the more likely members will seek concurrence with existing assumptions. When combined with prior success, or at least the perception of success, this also leads to the issues often cited in the organizational learning literature of "competence traps", "structural inertia", "the curse of knowledge", "core rigidities", "false knowing", "complacency", "defensive routines", and the "tyranny of the will". (Argyris, 1999, Camerer et al., 1989, Carlile, 2004, Hannan and Freeman, 1984, Leonard-Barton, 1995, Leonard, 2011, Levinthal and March, 1993, Levitt and March, 1988) Although it is possible for members of an organization, a project team, or even the decision maker themselves to locate decisions being made on tacit assumptions, there is a substantial risk they will be unable to identify all of the critical tacit assumptions behind their decision-making.

For a double-loop learning cycle to work in a creative industry, there must be an additional step of "locating decisions", preferably with the assistance of someone outside the team or organizational culture, that are being made based on "falsifiable tacit assumptions." The emphasis on "falsifiable" lies in the stated low likelihood that a double-loop learning cycle will change assumptions if it relies on confirmation rather than falsification.

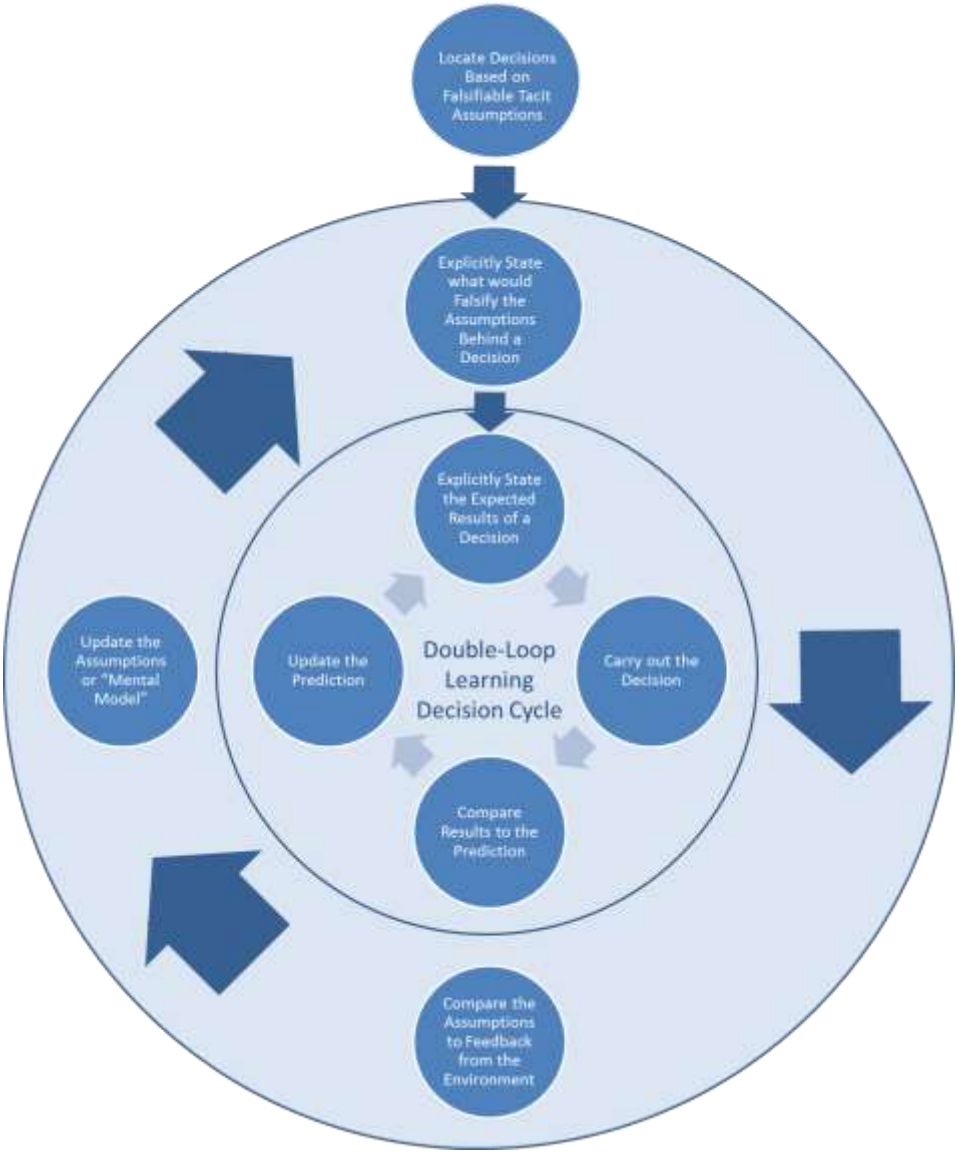

Figure 4-3. A double-loop learning cycle modified with Karl Popper's ideas regarding theory falsification and the additional step of locating decisions based on falsifiable tacit assumptions.

4.4 An Economic Approach to Validating and Updating Video Game Business Management Assumptions

Within the *Capability Maturity Model (CMM)*, organizational processes begin as chaotic, but organizations grow more mature as these processes are made repeatable, defined, managed, and finally optimized. (Humphrey, 1988) Data from the wider industry external to an organization is critical for moving through these steps because the quality of an organization's decisions depend on the decisions of the competition. For

an organization to be managed, it needs indicators showing whether it is succeeding. When predictions regarding these indicators are made and compared to results, the organization can finally calibrate, or optimize, its procedures to better fit the market. Managerial control requires making "corrective changes" if the "assumptions turn out to be wrong." (Ackoff, 1999, p. 157)

The framework proposed in this dissertation relies on a double-loop learning cycle, with some of the flaws that make it difficult to apply to a creative industry like video game development corrected through a focus on locating decisions based on tacit assumptions and seeking not to "confirm" those assumptions but to "falsify" them.

If video game development were merely a creative endeavor with artistic goals, it would be difficult, perhaps impossible, to falsify tacit assumptions and demonstrate that one decision has more value over another; however, in the context of business, an organization's decision-making success or failure is a managerial economics issue; are the results of decisions an organization makes with regards to its limited resources better or worse than the competition's? Value becomes quantifiable, and this is what allows data to inform the learning process in a creative industry like video game development.

However, it is important that this data is not just internally generated, but also obtained from external sources to, again, avoid confirmation bias. Data acquired from internal sources is generated from a decision-making process that could contain embedded mistaken assumptions. The result is a closed loop, where tacit assumptions frame the data being generated; the risk being that the data supports false assumptions in a form of self-fulfilling prophecy. In a creative industrial organization, where the products are intangible intellectual properties, the range of potential decisions is limited only by the imagination of the creators involved in producing the creative work. Such an organization can only afford to make a limited subset of all possible decisions in a market. As such, the success and future success of an organization relies entirely on the value generated by that subset of decisions versus the subset of decisions made by competitors. Data used to test assumptions against wider market realities must not only come from internal sources, but external sources and include the context of competition. This is why KDD techniques are critical for validating or falsifying the tacit assumptions behind the decision-making process. The final learning process, as an open loop incorporating data from outside of the organization, is depicted in Figure 4-4.

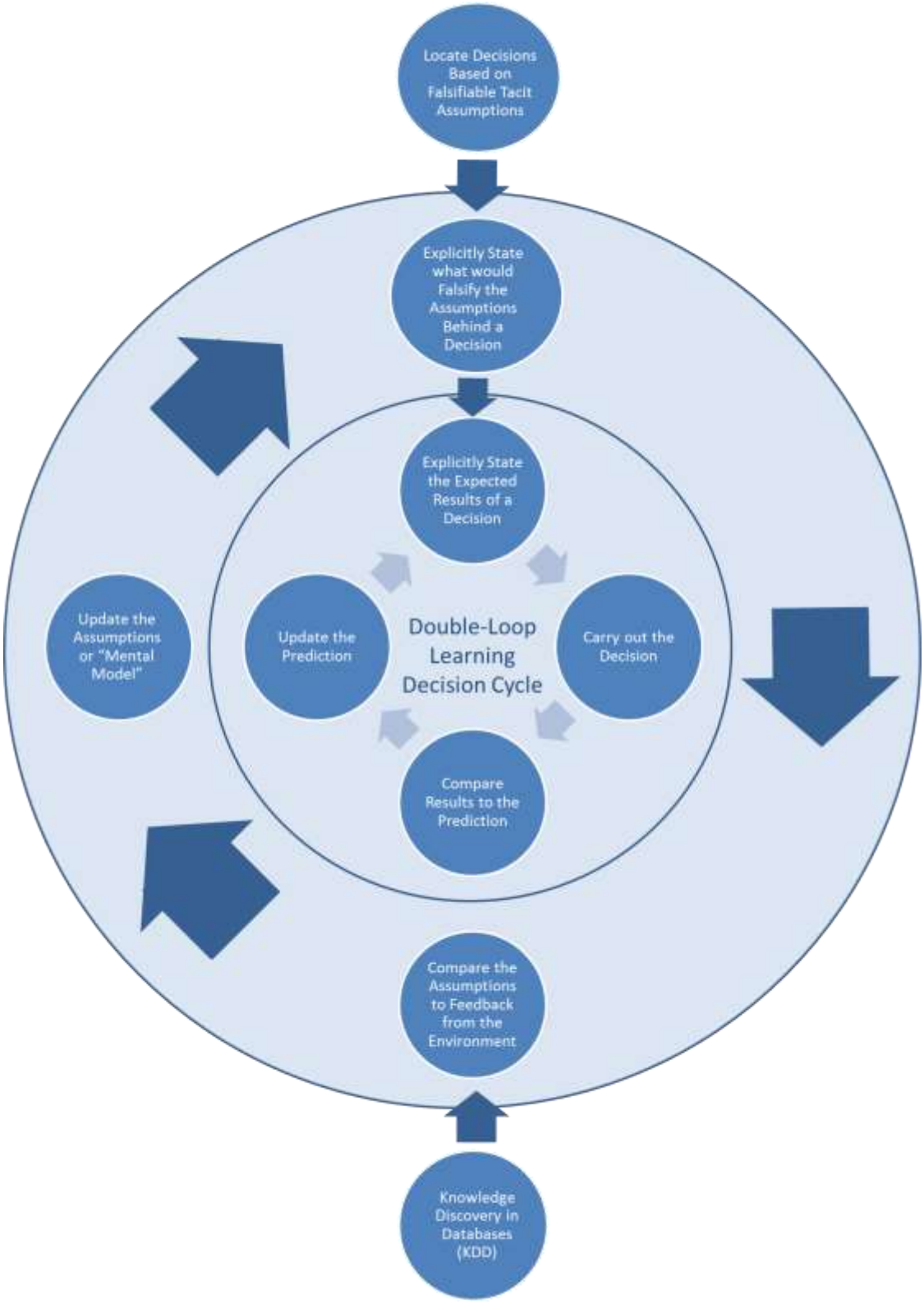

Figure 4-4. A learning cycle that incorporates tacit assumption location and knowledge discovery in databases (KDD) external to an organization.

The proposed learning cycle extends a traditional double-loop learning cycle to allow for the use of data to improve decision-making in a creative industry like video game development in two ways: first, it relies on observation from a member, preferably external to the project team or organization, to "locate" decisions made based on "falsifiable" tacit assumptions of the decision-maker; second, it stresses the importance of validating assumptions against external data sources – industry-wide data sources if they are available.

The first step is to, either by employing an external observer or soliciting observation from within the decision-making organization, locate decisions being made based on tacit assumptions that could be mistaken. One example from video game development is: we should create as much content as budget and schedule allow. The next step is to explicitly state the tacit assumption behind the decision. For the example, this would be: players prefer longer games, or, more specifically, players value a large content scope. This is not specific enough; however, and a managerial economics approach is required to truly state the assumption in the context of the value provided by limited resources. With an economics approach, the assumption becomes: given limited project resources, a fixed schedule, and a fixed price, players value content scope over quality. The next step is to employ KDD techniques to find data, or data sources, which could be used to falsify the assumption. In the example, this requires data that could invalidate the hypothesis that players value content scope over quality. This is still too abstract an assumption to test, so it could be transformed to the hypothesis that a determined ratio of players who purchase games like the one being developed will consume, and therefore receive value from, all of the content provided. In this case, a flag, such as an achievement or trophy, that marks whether a player has completed all of the content provided can provide the data necessary to falsify the hypothesis. Once the assumption has been explicitly stated, and a plan for falsifying or validating the assumption is settled, the data can be retrieved and analyzed. If the assumption was falsified, it can be updated for future decision-making. Worth reiterating is that evidence that falsifies an assumption is what should be sought, not evidence that confirms an assumption.

In the example, if the goal is to optimize the amount of content scope to reduce development costs, the hypothesis should be framed in terms of discovering what limit would determine that the content scope was "too much." In the example stated above, a falsifiable assumption could be: more than 20% of players will complete the intended amount of content. If the results reveal that less than 20% of players have completed the planned amount of content in similar games, then it is possible to conclude that the

assumption was mistaken and the understanding of how much content players consume may need to be updated.

Although the products and methods of economics can be used to optimize decision-making, one caveat to the proposed process is that it must recognize that, in a complex process like video game development, information is incomplete and decision-makers are operating with "bounded rationality." (Simon, 1957, Simon, 1972) It also must recognize that tacit knowledge is the source of most of the value in the symbolic products that are produced in a creative industry like video game development. The proposed process, with its focus on falsifying or validating assumptions suggests a "data-informed" – where data is used to falsify or validate tacit assumptions – rather than a "data-driven" approach – where data is used to make the decisions.

4.5 Executing the Economic Approach to Decision-Making in Video Game Business Decisions

The assumptions behind business decisions can be tested if falsifiable hypotheses are designed and verified using data gained from KDD techniques. This process is possible in a local context, with data from decisions on individual projects in a single organization; however, in an economic context, optimal business decisions cannot be considered in isolation. The decisions made by competitors change the business realities against which assumptions are verified. Business decisions must be framed against the decisions being made by the wider industry if they are to be optimized to reflect market realities. Chapters 5, 6, 7, and 8 will provide concrete examples of how KDD techniques can provide external knowledge regarding the state of the video game market and industry that can be used to falsify or validate tacitly held assumptions.

4.5.1 An economic approach to decision-making in innovation management within the video game industry

In Chapter 5, I analyze a game catalog of 6,222 games from 10 "third-party" console and PC game publishers from 1980 to 2018 to determine the ratio between exploration and exploitation of intellectual property (IP) in hit "AAA" video game console and PC publishers. In the *Capability Maturity Model (CMM)*, a publisher who makes a decision to accept or reject a game project proposal based on "gut instincts" regarding the viability of a project would be at the "initial" step, where decision-making

processes are undefined. If they were to remain consistent in the projects they accept and reject, they would be "repeatable." If they could provide the logic behind what makes them accept or reject a project, they would be "defined". If they followed through the results of their decisions to determine whether they were correct or not, they would be "managed". Finally, if they tailored their decisions to reject or accept a project based on those explicitly stated assumptions, they would be "optimized." External data that includes the ratios and relative success or failure of exploration and exploitation strategies allows an organization not only to optimize their decision-making processes locally, but globally. (Figure 4-5) Knowing that exploration projects tend to score lower *Metacritic* critic rating scores than projects based on exploiting existing video game intellectual property (IP), means they can "reframe" (Edmonson, 2012) expectations for critical response to exploration versus exploitation projects. They can also note that the overall ratio of exploitation to exploration in the AAA publishers sampled for 2018 is 13%, and that only 10 games from the top-ten best-selling game lists from 2001 to 2018 have been based on new IP, but that franchise revenue volatility peaks within the first few games and tapers, requiring the development of new franchises to bolster future growth before revenues from exploiting existing IP falls too low to support new developments.

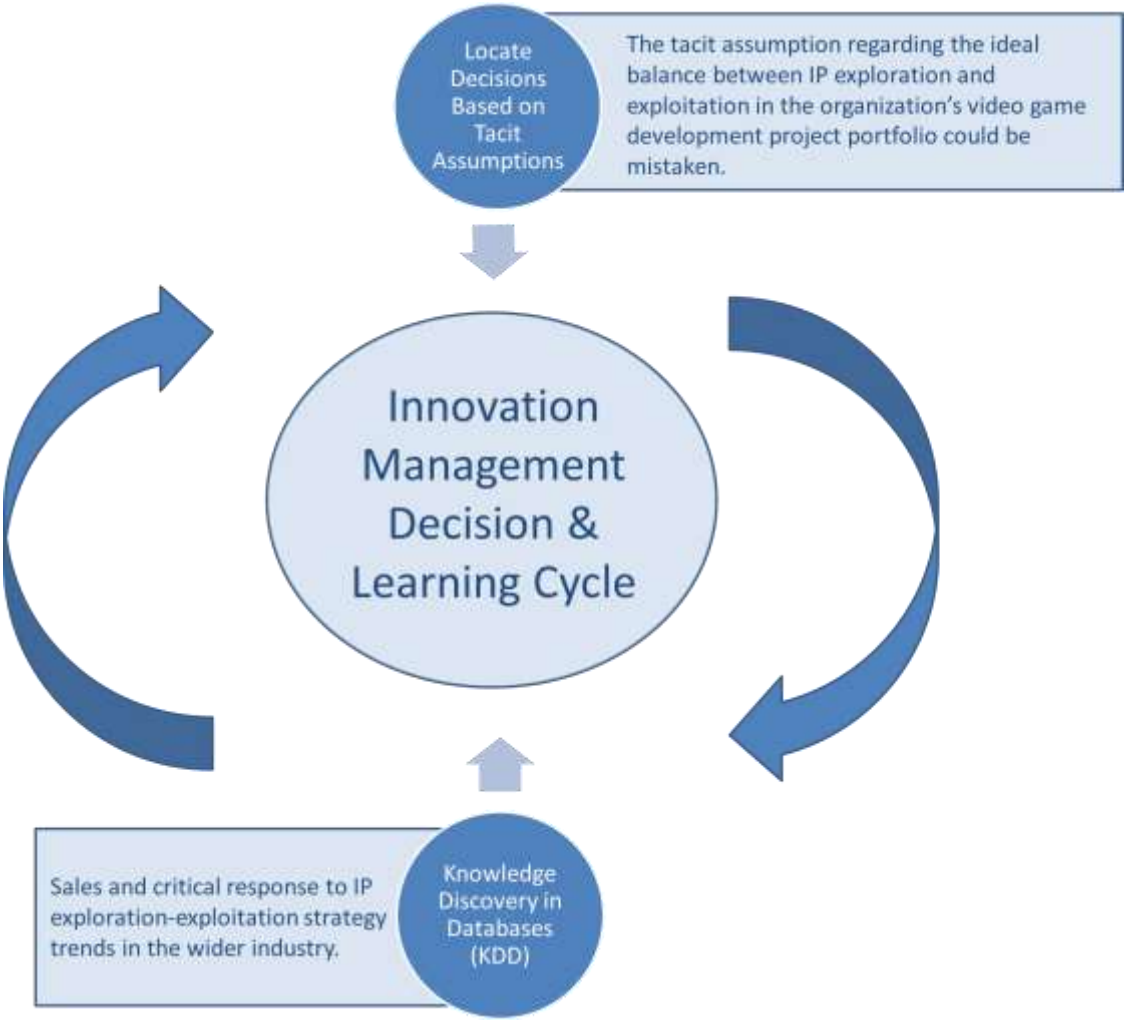

Figure 4-5. Incorporating industry-wide data to validate or position assumptions regarding exploitation-exploration strategies in intellectual property (IP) development in video game organizations.

4.5.2 An economic approach to decision-making in human resource management in the video game industry

In Chapter 6, I analyze 14,265 staff from 27 representative "AAA" best-selling games to determine gender ratios, broken down by whether they are development or support roles, well-paying roles, or leadership roles. This data shows that, not only is overall gender diversity in video game development limited and not reflecting the audience, but that diversity is even more limited for leadership, or creative decision-making roles. This has serious consequences for the diversity of experience involved in the decision-making process, given that women comprise nearly half of the

target audience. (Entertainment Software Association, 2019) Although the issues outlined in Chapter 6 make it difficult to update organizational human resources to reflect the diversity of the wider player population, an awareness of diversity shortcomings makes it possible to incorporate knowledge regarding gender gaps into the human-resource (HR) or "talent management" decision cycle. (Figure 4-6)

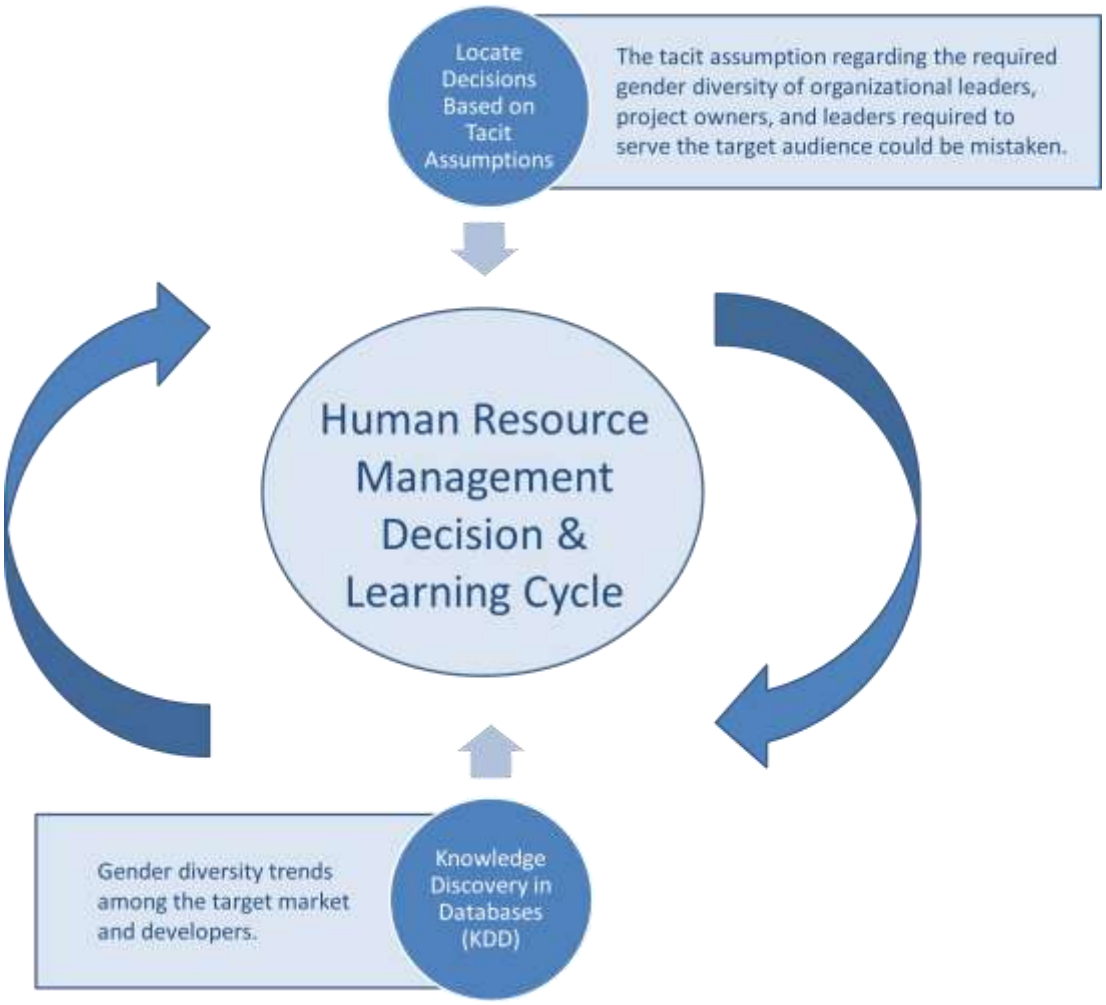

Figure 4-6. Incorporating industry-wide data to validate or position assumptions regarding gender diversity and representation in video game organizations.

Left unmanaged, the decision to hire or promote an employee is based on tacit assumptions regarding who "fits" the job. However, there is a tendency for hiring and promotion to follow a self-selecting bias – people tend to hire and promote people like themselves, which reduces diversity. Schneider (1987) described the "Attraction-Selection-Attrition (ASA) Cycle" where an organization grows less diverse over time because they attract the kind of people who create the organizational culture

and turn away or turn off the kind of people who would change the culture. A "managed" HR process would make gender ratios broken down by position and diversity goals visible, while an "optimized" HR process would ensure that day-to-day decisions, including hiring, retention, and promotion, reflect the diversity goals of the organization. For a video game organization to understand how well its gender diversity efforts are faring, it needs to understand where it is at in relation to the rest of the industry. Does it have fewer women in leadership than other companies? Do its development teams or certain functional groups in those teams run the risk of losing the women they have because they are dominated by men?

Gender diversity is only one aspect of the diversity video game organizations require to respond to a changing market – demographic diversity such as gender identity, ethnicity, age, religious beliefs, nationalities, socioeconomic status, and disabilities as well as cognitive diversity such as education and culture can all produce effects on the decision-making process. However, diversity is one area where incorporating external knowledge is critical to moving in an appropriate direction, because left alone, the tendency is to self-select and revert to a homogenous culture that limits the potential for innovation and filling the needs of a more heterogeneous consumer base.

4.5.3 An economic approach to decision-making in project management in the video game industry

The tacit assumption in video game development tends to be "more is better" for the consumer when it comes to both content and functional scope. However, in Chapters 7 and 8, I analyze data from the most popular PC game marketplace, *Steam*, to discover the extent to which consumers value the content and functional scope of the video games they purchase and play.

In Chapter 7, I analyze data for 31,964 entries on *Steam* for games and applications released 2005 to 2017. For the 725 entries employed in the sample, only 14% of players on average had reached the end of the "single-player", "main-path" content. The ratio of players experiencing content that justifies its development cost depends on the costs and risks involved in development versus sales and revenue; however, left unmanaged, video game project teams could be devoting resources to developing content that few players value. An awareness of how much content players consume overall, in similar genres, and in similar games, makes it possible to use that knowledge to improve project management decisions. (Figure 4-7)

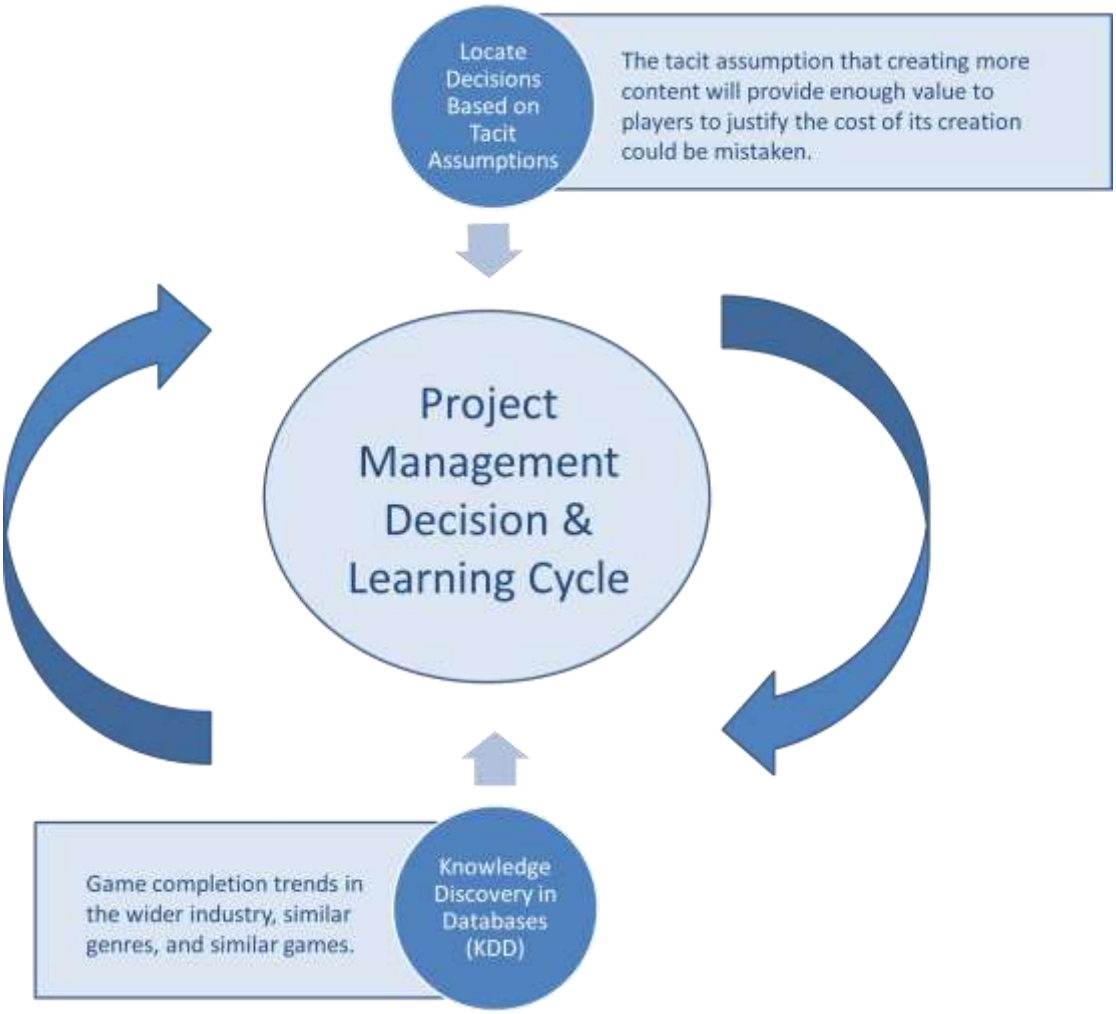

Figure 4-7. Incorporating publicly available Steam achievement data to validate or position assumptions regarding the amount of content players value in their games.

An example provided in Subsection 7.4.3 demonstrates how locating a decision based on a tacit assumption and incorporating KDD techniques modified the decision-making process. In this example, content completion data for a virtual reality (VR) title similar to the one being developed was gathered and used as a benchmark for how much content, in terms of playing hours, would be sufficient for players. The tacit assumption that eight hours was an appropriate length for playtime was updated to five hours, based on external data, with resources instead devoted to improving quality.

In Chapter 8, I analyze data for 34,263 entries on *Steam* for games and applications released 2005 to 2017 to determine when a functional scope decision, the decision to include a "multiplayer" mode in a video game, adds value for players. Multiplayer modes are complex and expensive to develop, and with limited resources,

the decision to include them can come at the expense of other features or carry risks with completing the project on time or on budget. Basing this decision on a tacit assumption that multiplayer adds value could be risky to an organization if that assumption is mistaken. Incorporating external knowledge from the wider industry, similar genres, and similar game projects gives decision-makers a better understanding of how much value a multiplayer mode could add to their project. (Figure 4-8)

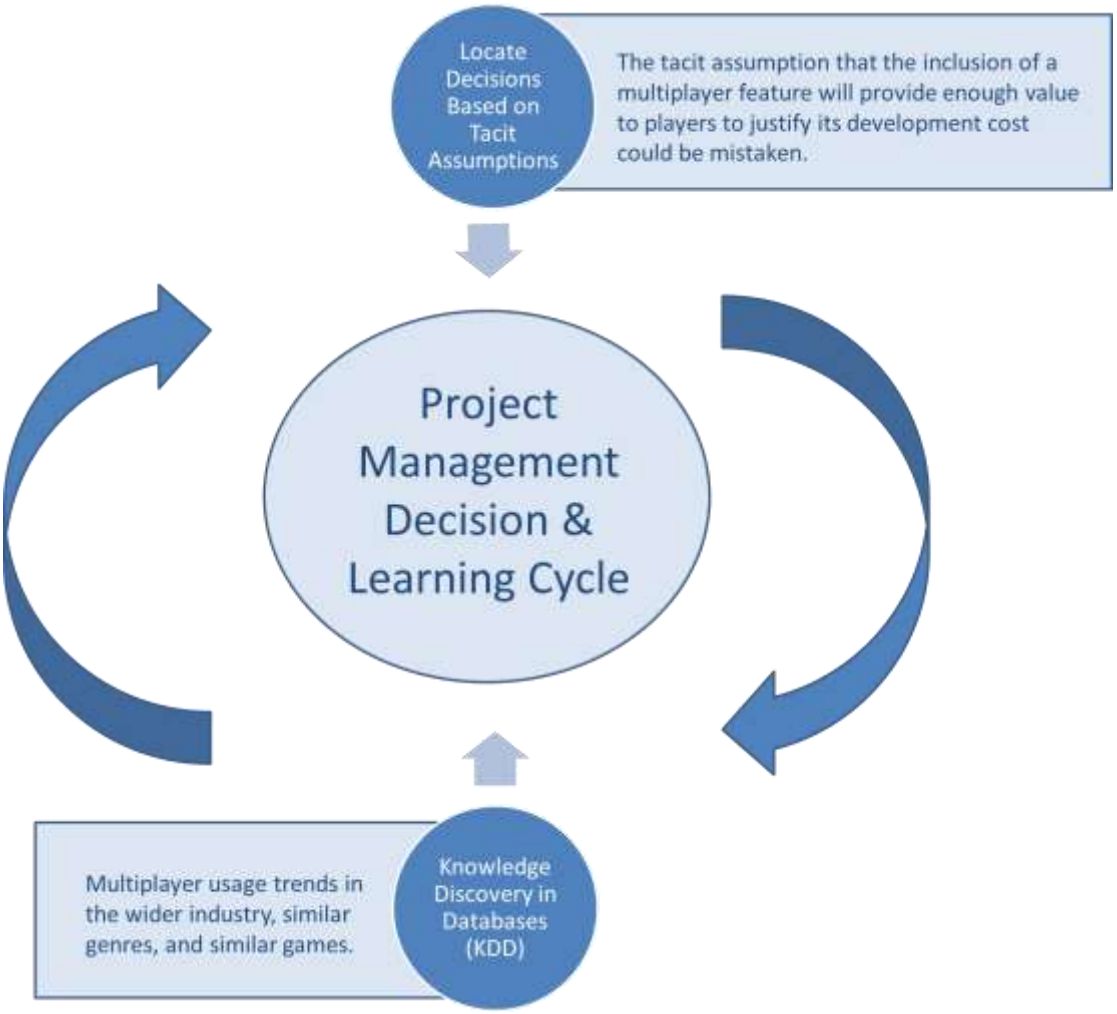

Figure 4-8. Incorporating publicly available Steam achievement data to validate or position assumptions regarding whether players value the inclusion of multiplayer functionality.

The analysis in Chapter 8, for example, would make the decision to include multiplayer less valuable in cases of games with resources devoted to developing strong single-player content because there is a lower likelihood that multiplayer features will be used by players. "Multiplayer" is only one functional scope decision, but there are

many others that can grow expensive to implement and the decision to include them in a video game project should not be based solely on what could be a mistaken tacit assumption regarding the value they provide to players.

4.6 Implications of an Economic Approach to Decision-Making in the Video Game Industry

The research introduced in Chapters 5, 6, 7, and 8 provides examples demonstrating the potential of using KDD techniques on data external to an organization to falsify or validate tacit assumptions that drive decision-making in video game business management. Video game organizations must learn how to incorporate data from the industry and use it to test not only decisions, as in a single-loop learning cycle, but the assumptions behind those decisions, in a double-loop learning cycle, if they want to improve their chances of survival.

This chapter proposed a process that answers the question:

- How can an economic perspective that views decision optimization in terms of making the best use of limited organizational resources allow for the use of data from the wider industry to question assumptions and improve video game business management decision processes?

The process presented extends a typical double-loop learning and decision cycle in two important ways (Figure 4-9): first, it relies on observation from a member, preferably outside the project team or organizational culture, to "locate" decisions made based on falsifiable tacit assumptions of the decision-maker; second, it stresses the importance of validating assumptions against external data sources – industry-wide data sources if they are available. The perspective provided by the field of managerial economics, with its focus on optimizing the decision-making process and employing limited resources to provide the greatest business value, is critical for allowing data to inform the decision making process in a creative industry, such as the video game industry, where otherwise artistic ideas of which decisions provide the most "value" would prevent attempts at organizational learning – a result that would have consequences to a business organization attempting to succeed in a growingly competitive market. While this is a data-informed learning cycle, it recognizes the

central role tacit knowledge plays in generating value in a creative industry. Data or the possible resulting business intelligence or decision support systems do not replace the decision-maker, they help the decision maker discard falsified knowledge and update their assumptions to better reflect the underlying and ever-changing market realities of the creative industry so that their creative inputs can produce the most value from the limited resources available.

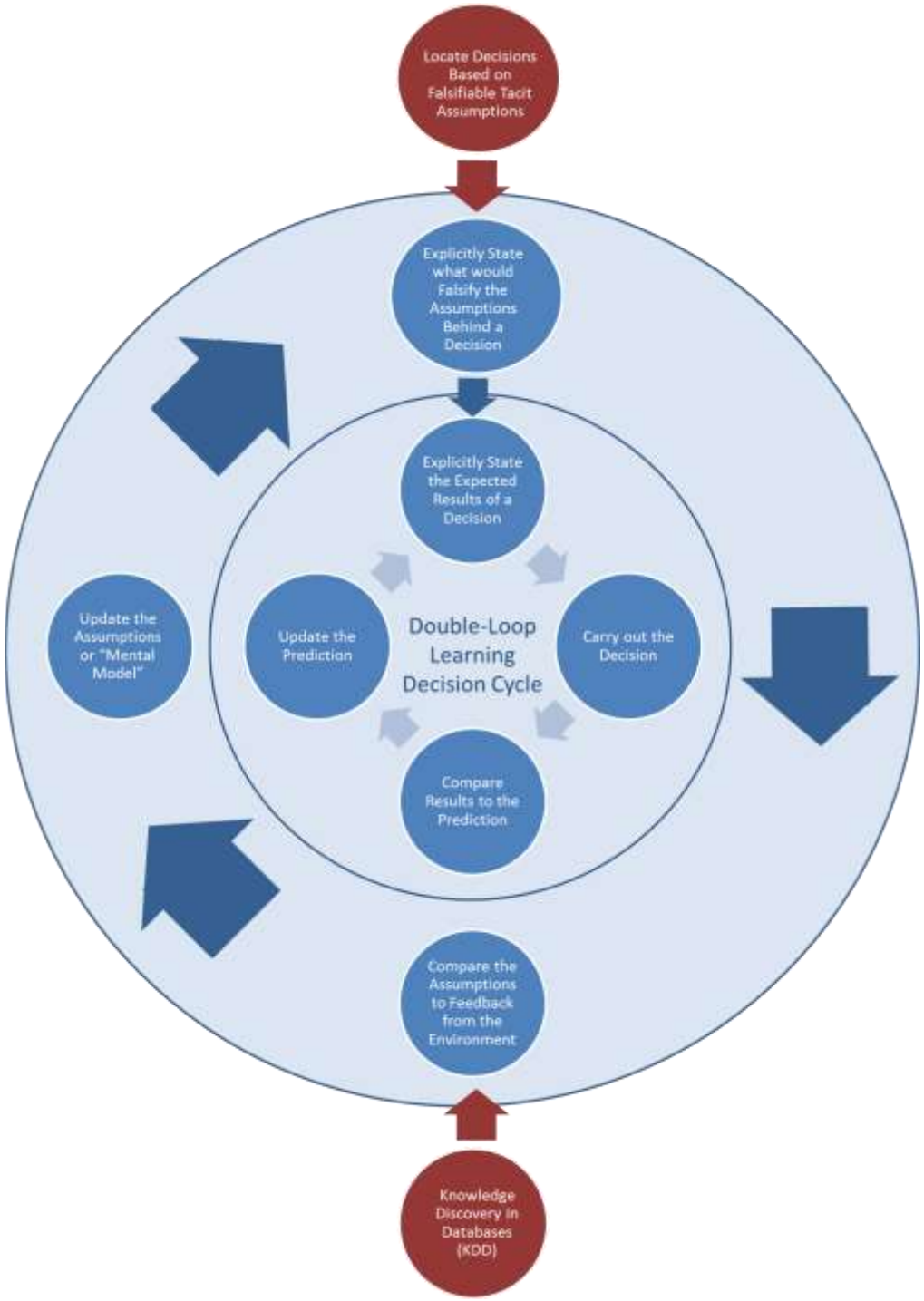

Figure 4-9. Extending the traditional decision cycle by locating decisions made based on falsifiable tacit assumptions and falsifying or validating those assumptions using KDD techniques with data sources external to an organization.

When applying the principles of economics to software engineering, Boehm (1984) described economics as the "study of how people make decisions in

resource-limited situations." A managerial economics approach to decision-making is aware that decisions must be optimized given limited resources. An economic approach also situates decision-making globally, not locally, by considering the subset of decisions made against the subset of decisions made by competitors. The tacit assumptions underlying business decisions are viable only if they are optimal given the situation of the decision-maker in the context of their competitive environment.

The video game industry, like other creative industries, relies heavily on the experience-based tacit knowledge of its managers and workers to generate value and make decisions; however, with high turnover and video game projects requiring years to develop, this experience is necessarily limited. The video game market is also rapidly evolving, quickly invalidating knowledge that may have proven useful in the past. (Parkin, 2018) Video game organizations need to be aware of the traps of relying on tacit knowledge and strive to improve decision-making processes by locating decisions based on tacit assumptions and falsifying or validating those tacit assumptions using KDD techniques on data from the wider market.

5. A Quantitative Analysis of Exploration-Exploitation Trends in Top Video Games and Publishers

In Chapter 5, I analyze innovation trends, specifically the balance of exploration and exploitation activities, within video game research and development. The results provide an answer to the question:

- What is the state of intellectual property exploitation and exploration strategies in innovation and business management practices within leading video game organizations and how are those strategies changing?

Video game development is a creative endeavor. Game players demand new experiences, which requires innovation from developers. However, developing a new video game intellectual property "franchise" is a high-risk business decision, given the rise in video game development and marketing budgets and the difficulty of creating a "hit" needed to recoup expenses. Exploiting organizational competencies in developing an existing intellectual property franchise is one way to improve efficiency. When faced with the choice of exploiting a proven franchise or exploring a new one, publishers face a difficult decision. However, the extent to which publisher exploration behaviors have changed over time has yet to be fully examined through a quantitative approach.

Exploitation strategies hedge risk, and the average franchise age of the annual top-ten best-selling games continues to grow older, yet exploiting a proven intellectual property in the entertainment industry has pitfalls – primarily the difficulty of keeping a series fresh for players. Based on an analysis of 6,222 games from 10 publishers, this research into the trends of "third-party" console and PC game publishers from 1980 to 2018 discovers they are growing more conservative, with only 13% of their combined game catalog exploring new franchise possibilities in 2018. Using aggregate critic scores and top-selling game data, I also explore how publishers' exploitation strategies are being rewarded and reinforced.

5.1 Decision-Making Processes in Video Game Development

Publishers with limited resources to commit to video game projects must decide between exploring potential new intellectual properties (IP) and exploiting proven

franchises through sequels or tie-ins with non-video game licenses such as professional sporting leagues or movies. Despite the rise of independent game development, large publishers control most of the video game market, with an estimated 77% of global game revenues being captured by the top 25 companies. (Wijman, 2018)

This chapter explores the decision-making processes at the eight largest third-party publishers of console and PC video games as well as two large game publishers that have gone bankrupt over the course of the time period surveyed. Game release catalogs for the 10 publishers in the sample were compiled, and each of the 6,222 games included was tagged according to whether it was new, based on a prior game, or based on an existing entertainment intellectual property license, such as a movie or a book. When available, aggregate critic scores were also gathered for each game. Trends in the changing ratio of new games to franchise games over time, trends in top-selling games, and critical reactions were analyzed to determine whether there is a shift in exploration versus exploitation strategy within each publisher and across the industry, and whether those strategies are being rewarded and reinforced through review scores and sales. Through this analysis, we show that game publishers have reasons, backed by data, for shifting to and relying on an exploitation-based strategy, but that this strategy limits potential growth.

5.2 Cultural and Creative Industries as a Model

Greater attention is being paid to the "cultural" or "creative industries" (Florida, 2002) as models for the way business is changing in the "knowledge economy." (Drucker, 1969) The need to provide culture consumers with innovative new content entails risks, and "chart-driven" creative industries such as the movie industry are forced to rely on "hits" to make up for the many losses that a strategy focusing on innovation entails. (Hesmondhalgh, 2008, Jeffcutt and Pratt, 2002) Rising development and marketing budgets mean the video game industry faces similar problems in balancing the needs of exploration and exploitation and the search for the "ideal" level of innovation in their products. As Tschang (2007) discovered through qualitative research into game development, increasing complexity in developing "hit" games has led to rising rationalization in favor of investing in proven game franchises and genres.

5.2.1 Creative management in video games

The video game industry is hit-driven, like many other creative industries such as movies or music. (Bakker, 2010, Hirsch, 1972) In order to generate hits, large

budgets, in some cases surpassing $100 million for development alone (Bleeker, 2013), are required to generate the content and marketing behind games that will stand out in the market and become a best-seller that year. With budgets that large, failure can put even a large publisher out of business. Two publishers included in this research, *Midway Games* and *THQ*, went bankrupt because they were unable to receive a strong enough return on their video game development investments. Yet the rewards for success are high. The game *Grand Theft Auto 5* may have cost $265 million in development and marketing, but it has reached a record $1 billion in revenues. (Bleeker, 2013) The video game industry is a winner-take-all market. (Frank, 1995)

One of the problems with choosing projects in creative industries is that "nobody knows" what will succeed in the market. (Caves, 2000, De Vany and Walls, 1999) The value of an experiential product like a video game depends on consumer perception. (Bilton and Leary, 2002) Game players choose to buy new games because they want something new that old games will not provide. However, how much "new" is required to make a sale is a difficult question to answer because consumers often want "accessible" and "familiar novelty". (Lampel et al., 2000) When trying to develop new intellectual properties, many video game companies rely on a stage-gate process to decide which projects go forward or get cancelled; however, concerns have been raised that the stage-gate process is not useful for evaluating innovative games. (Cohendet, 2017) Managers in any cultural industry must balance the "expression of artistic values with the economics of mass entertainment." (Lampel et al., 2000) Unfortunately, video games require high, upfront labor costs to develop, and, although hits can generate large revenues at small addition cost, "flops can quickly turn into a major financial disaster." (Aoyama and Izushi, 2003) To avoid risks associated with growing costs, gatekeepers in game development organizations prefer imitative games. (Tschang, 2007) In other creative industries, large publishers, as opposed to "independents", are known to prefer proven solutions. (Peltoniemi, 2015)

Tschang (2007) noted that, in addition to financial risks, increasing video game product complexity is another reason that gatekeepers deciding whether to pursue a project are likely to prefer incremental innovations. In Markham et al. (2010)'s theory of roles, the "gatekeeper" is the person or people responsible for deciding whether a proposed project will be approved for further development. Without knowing whether a radical new idea will succeed or not, the gatekeeper, whose responsibility is the success of the business or business division, will likely prefer proven ideas. Exploiting organizational competencies in developing an existing intellectual property franchise is one way to improve efficiency, so even if many potential games are proposed, radically

innovative ideas could be less likely to pass through the gate into the production process.

Consumers want variety, while producers incur costs and cannot predict what will sell, so entertainment industries tend to support the variety that the market can sustain while providing producers with enough payback to justify their costs. (Bakker, 2014) As the stakes for failure rise in the video game industry, this balance could be shifting over time, which leads to the first hypothesis of this chapter's research:

- H1: Large third-party video game publishers are growing more conservative, producing fewer games and more games based on existing intellectual property franchises.

5.2.2 Exploration and exploitation strategies

March introduced the concept of exploration and exploitation of knowledge in organizations. (March, 1991) The balance between the two strategies is critical for publishers trying to make the most of their video game development investments. (Hotho and Champion, 2010) Consumers buy new games because they want something "new"; if they were satisfied with existing games, there would be no reason to buy new ones. Too much reliance on exploitation alone could fail to provide consumers with new-enough experiences and lead to the kind of franchise fatigue that has occurred in cases such as publisher *Activision's Guitar Hero* series. (Yoon, 2009) When this happens, new franchises must rise up to replace the existing ones. However, as with most exploration strategies, developing new franchises is risky and expensive.

In addition to the market reasons, organizations also prefer to repeat what they know. With another cultural product, movies, it has already been demonstrated that sequels result in higher profits. (Walls, 2009) Competence in existing procedures makes experimentation with new procedures less attractive; organizational routines capture past experience and tend to be changed only when forced to be changed because the existing behaviors no longer allow organizations to meet their targets. (Levitt and March, 1988) In this way, learning inhibits experimentation. (March, 1991) Even if a video game development organization's professed goal or vision is to develop innovative, creative video game products, if the results reward incremental innovation, then decisions and routines could lead to a different "enacted schemata." An organization's

"espoused schemata" and "enacted schemata" may differ if routines, through trial-and-error learning, begin to reflect a different reality than what is espoused. (Rerup and Feldman, 2011) Exploiting what an organization knows is a rational strategy, as long as it works, which leads to the second hypothesis of this chapter's research:

- H2: The intellectual property exploitation strategy in video game publishing is being rewarded and reinforced through sales and critical response.

5.2.3 The need for innovation

Relying on prior experiences that led to success in an industry that depends on "hits" may lead to an illusion of control. (De Vany and Walls, 1999) Cultural goods such as video games are experiential goods, where the value is decided after consumption. (Lampel et al., 2006) Predicting success is difficult for complex products when the final value is determined by the consumer; decisions to follow an exploitation strategy could be based on inertia in the organizational culture, rather than strategy. (Bilton, 2007) If the environment changes, then knowledge from the past could be rendered irrelevant, and worse, if organizations rely on prior knowledge to guide their exploitation activity, the lapse in exploration activity means they are not generating the new knowledge necessary to adapt to those changes. (Adler et al., 2009) For these reasons, one risk with competence is it can become a trap that prevents an organization from exploring superior activities. (Andriopoulos and Lewis, 2009, Herriot, 1985) Although exploitation is often preferred because it is seen to reduce risk, another problem with defaulting to an exploitation strategy is that other firms will often default to the same strategy in order to increase their own survival – the result is that firms will come to resemble each other, inhibiting innovation. (Ordanini et al., 2008)

Using the example of the automobile industry, Abernathy (1978) first described the "productivity dilemma" that occurs over time as industries seek efficiency and shift from product innovation to process innovation and finally stagnate and lose their ability to innovate. Wada et al. (2014) noted the "platform paradox" that has occurred within the video game industry, as companies develop games using the same, shared "game engines" as one method of cost reduction. Another method for mitigating risk is to exploit genres and intellectual properties that have already proven successful in the

market. Ikuine (2006) performed an empirical analysis on Japan's video game software industry from the 1980s to 2000 and discovered that developers were relying more heavily on sequels as they entered the 1990s. He considered this to be the reason for the shrinkage of the Japanese video game market in the 1990s.

Success with entertainment products is easy to judge in retrospect, but predicting it is difficult. (Negus, 1992) Recent video game hits such as *Minecraft* and *PlayerUnknown's Battlegrounds* did not come from the major publishers but emerged from independent developers. Video game organizations must perform "both their exploration activities to renew their procedures and cultural products" and "their exploitation activities to optimize their productions and amortize their creations" through the use of existing intellectual properties. (Parmentier and Picq, 2016) Knowledge helps to make a firm's performance more reliable, but at the potential expense of being the best. (March, 1991) Core capabilities can become core rigidities if the economic environment changes. (Leonard-Barton, 1992) Although organizational routines based on prior experience can help make an organization more efficient, a strong focus on efficiency can lead to a crisis in creativity. (Bilton and Leary, 2002, DeFillippi et al., 2007) There is also the risk that what works at one time may not work in the future and firms that stop innovating may eventually lose to firms that innovate in the long run. (Lampel et al., 2006) As with the *Guitar Hero* franchise fatigue that occurred when publisher *Activision* relied too heavily on that intellectual property's success, over time it becomes more difficult to present an existing idea as something new for consumers, and a series that runs too long could experience diminishing returns, which leads to the third hypothesis:

- H3: Large video game publisher reliance on an intellectual property exploitation strategy sets a limit to growth potential as later sequels are less likely to attract new players or create new markets.

5.3 A Quantitative Approach to Analyzing Exploration and Exploitation Strategies in the Video Game Industry

This research employs a quantitative approach to investigating the video game

publisher decision balance between devoting R&D resources to exploration and exploitation. We combine data from multiple public sources and construct game catalogs with relevant information, including sales and critical response, for the eight global, top revenue-generating third-party video game console publishers in 2017 as well as two large publishers that went bankrupt during the observed time frame. We then examine the game catalog and identify franchise video games that rely on prior games or intellectual properties outside of the video game industry. Through analyzing the 6,222 games in this catalog released from 1980 to 2018, as well as the top-ten best-selling games from 2001 to 2018, we will verify our three hypotheses.

5.3.1 Research scope

This research focused on third-party console and PC video game publishers in the top 25 video game publishers by revenue in 2017. We did not include first-party hardware platform holders, such as *Nintendo*, *Sony*, or *Microsoft*, who are also publishers because their innovation policies are likely to favor promoting their platform, supporting a certain technological feature for example, even at the expense of standard business objectives and would therefore differ from those of third-party publishers. Also, mobile video game publishers were not included, as their innovation practices would differ from console and PC publishers given the different market, development costs, and business model they employ. Our decision to focus on large publishers is based on the current result that the top 25 publishers control 77% of the global games market. (Wijman, 2018)

Within the publisher game catalog, only arcade, PC, or video game console games, including those for handheld systems, were included. This excludes mobile games released by the publisher for the same reasons mobile publishers were not included in this research.

Aggregated critic data is available for most recent releases, but such data is sparse for games released prior to the year 2000, limiting the time period we could analyze the link between intellectual property decisions and critical rating results to the last two decades. More recent releases might not be fully reviewed, so to avoid noise, only data up through 2018 was included. For these reasons, only critic ratings from 2000 – 2018 were analyzed.

Video game sales data also faces the same limitations as critic rating data. Reliable sales data for games prior to 2000 was difficult to obtain, so early entries in a long-running video game series do not have sales numbers attached. As the goal of this

research is to focus on sales trends over the course of the series, with a focus on the sales direction for more recent releases, this does not adversely affect the analysis.

5.3.2 Data sources

The primary sources of game titles released by each publisher were websites *Wikipedia* and *Metacritic*. Aggregated critic ratings were also obtained from *Metacritic*, a web site that aggregates reviews from various media sources and compiles them into a single representative score "based on their quality and overall stature" using a proprietary weighting system. (Metacritic, 2018) *Metacritic* ratings are an aggregated score of critics' ratings for games ranging from a low of 0% to a high of 100%. According to *Metacritic*'s guidelines, 0 – 49% is "unfavorable," 50-74% is "mixed" or "average," and 75-100% is "favorable." (Metacritic, 2018) *Metacritic* scores are considered a sign of a game's "quality" and are sometimes used by publishers to judge the quality of their developers' final products for purposes of bonuses (Gilbert, 2012) because there is an established correlation between review scores and sales. (Greenwood-Ericksen et al., 2013) For a comparison of critical ratings with large publishers who were unsuccessful in maintaining their business, we have also included data from *Midway* and *THQ* – two large publishers that went bankrupt in 2009 and 2012, respectively. Although the weighting algorithm is not made public, the system is applied consistently, allowing for the relative comparison employed in this research and was favored over the use of individual site or critic scores for the balancing effect that results from aggregating scores.

Information about individual game revenues came from *VGChartz*, a business intelligence and research firm that publishes sales estimates for video games on their website. Unfortunately, video game sales are not typically made public in the way that movie box office receipts are, so analysts from any firm can only estimate sales. *VGChartz* uses proprietary methods for estimating sales data and the results are "regularly checked against manufacturer shipments and data released publicly from other tracking firms to ensure accuracy." (VGChartz, 2019) This research uses sales for comparative purposes over the lifetime of a series, so as long as the estimating procedure remains the same, it can still provide an estimate for how a game franchise is doing over time.

Lists of the top-ten best-selling games for each year from 2001 to 2018 were obtained from data released by market research company, *The NPD Group*. For video games, *The NPD Group* tracks retail sales and their service "covers all distribution

channels, including online sales." (The NPD Group, 2019) The top publishers by revenue in 2017 were based on market intelligence firm *Newzoo*. The ranking is "based on analysis of annual and quarterly financial reports published by a number of relevant publicly listed game companies." (Newzoo, 2018) The financials are estimated for companies that do not separate game revenues in their reports.

Publisher financials were retrieved directly from annual reports issued by the companies themselves. For the purposes of this research, only companies that receive revenues primarily from game publishing were investigated, which excludes *Bandai Namco*, *Warner Bros*, and *Konami.*

5.3.3 Tagging originals and intellectual property franchises

Like movies, video games often label their video game sequels with numbering or secondary titles. In such clear cases, games were soon tagged as sequels. However, games may sometimes be based on an existing intellectual property franchise in a way that is not obvious from the title, particularly games that are based on franchises outside of the video game industry. To correctly tag these games, the rest of the entries in the compiled catalog were manually checked using various internet sources obtained through title and keyword searching via *Google*. Games based on existing franchises were also divided into sequels and games based on non-game and non-sport intellectual properties in case trends for the two diverge. The decision to separate sport-based titles from other entertainment-based franchises was made because sports have clear game-like rules that can be transferred to video games as opposed to movies or books, where only story or world elements transfer. The final game catalog contained an entry for each game, grouped by publisher, with a true or false value for being "new and unlicensed", a true or false value for being based on an external, non-sports entertainment license, a true or false value for being a mobile game, a release year, and a *Metacritic* score.

Statistics for each company were aggregated from the data in the compiled game catalog. The total number of released games, the number of "new" games, the number of games based on prior video games, and the number of games based on non-game and non-sport intellectual properties were calculated. The number of new titles compared to each company's game catalog were calculated and trends for the period from 1980 to 2018 were explored. In addition, the average *Metacritic* scores were calculated for each category to discover any differences in the critical response to different franchise strategies.

5.4 Decision Strategies in Top Video Game Publishers

The publishers chosen for investigation were based on *Newzoo*'s top 25 game publishers in 2017 by revenue list. (Newzoo, 2018) Video game consoles and PCs have been a market for more than 40 years, making them a comparatively stable source for comparison compared to other, newer video game markets. This is particularly useful when analyzing changes over several games in a long-running franchise series. We have not included mobile game-focused publishers, such as *NetEase* or *Netmarble*, or online game publishers, such as *Tencent* or *Nexon.* In addition to the stability reasons stated, the differences in the markets in which they operate, the development style and team compositions required to create them, and their relatively recent emergence as separate markets would make direct comparisons with AAA console and PC game publishers inappropriate. Hardware platform holders such as *Sony*, *Microsoft*, and *Nintendo* were not included because their innovation objectives, around making their platform a unique value proposition, would likely differ from those of third-party publishers.

In addition to the revenue numbers reported by *Newzoo*, the revenues reported in the annual reports for fiscal-year 2017 were also verified and reported. In cases where publishers have multiple sources of revenues, the revenues from the digital entertainment business were reported. Yen and euro-to-dollar conversions were based on the exchange rates posted for the year ending 2017 by the *U.S. Department of Treasury*. In addition, two large publishers that went out of business after the year 2000, *THQ* and *Midway*, are also included for comparison purposes. The publishers examined for this research, with information on their revenues and the number of games in the sample is listed in Table 5-1.

Table 5-1. List of video game publishers analyzed, their revenues reported for their game divisions in annual reports for fiscal year 2017, the estimated game revenues from *Newzoo* along with the estimated percent change from 2016, the *Metacritic* score average for games in their catalog after 2000, and the total number of games analyzed for the sample.

Publisher	Founding Year	Annually Reported Total Revenue for FYE 2017 (in millions of US dollars)	Newzoo Total Revenue for 2017 (in millions of US dollars)	Newzoo % Change from 2016	Post-2000 Metacritic Average	Games in Sample
Activision	1979 /	7,017	6,513	4%	69%	630

Blizzard	1991					
Electronic Arts	1982	4,845	5,095	10%	76%	1159
Bandai Namco	1950 / 1955	3,259 (380,273 JPY)	2,428	22%	68%	767
Ubisoft	1986	1,582 (1,460 EUR)	2,208	38%	68%	645
Warner Bros Interactive	1993	1,936	1,936	21%	71%	153
TakeTwo Interactive	1993	1,779	1,914	21%	71%	581
Square Enix	1986 / 1975	1,706 (199,000 JPY)	1,743	5%	73%	701
Konami	1969	905 (105,573 JPY)	1,079	33%	67%	1028
THQ	1989	-	-	-	66%	407
Midway	1958	-	-	-	65%	170

Activision Blizzard, fifth in the top 25 publisher by revenue list, earned between 6.5 and 7 billion dollars, which is roughly 6 times the revenue of 20th place *Konami*. Video game publishers that have been around from 1980, the beginning of the sampling period, such as *Electronic Arts* (1,159) and *Konami* (1,028), have a larger number of games in the sample compared with more recently founded companies such as *Warner Bros Interactive* (153) – the game division of the parent entertainment company. *Electronic Arts* is the only video game company to maintain a "favorable" mean *Metacritic* rating above 75% for its games since 2000. Both *THQ* and *Midway*, the two companies that have gone out of business, had lower average *Metacritic* ratings (66% and 65%) than the other companies.

5.4.1 Trends in the number of games released per year

After peaking in the year 2000 with 282 games, the eight still-existing publishers sampled are releasing fewer titles per year, down to 98 in 2018 (Figure 5-1). This is likely due to the growing costs and development efforts required per title.

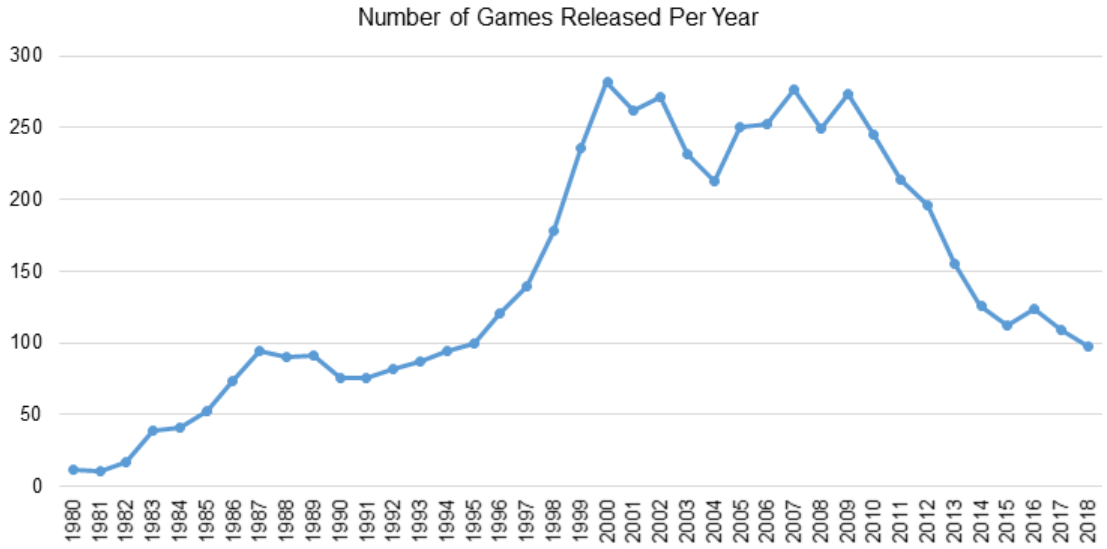

Figure 5-1. The trend in total number of games released per year for the eight still-existing publishers in the sample from 1980 through 2018.

The original *Call of Duty*, released in 2003, required a development team of 42 people, while *Call of Duty: WWII*, released in 2017, required 564 people, based on a manual count of the development staff listed, not including support staff. Given industry statistics that an average employee costs a studio around $10,000 per month, or $120,000 per year (Schreier, 2017b), that is a difference between $5,040,000 per year and $67,680,000 per year for a full staff. In the *Call of Duty* case, *WWII* has generated over $1 billion in revenues, according to *Activision*. (Makuch, 2018) While "hit" titles recover their budgets, these staff sizes and budgets would make it difficult to simultaneously produce as many titles as in the past. The economics lead to fewer, but larger bets – a factor that leads into the choice of new or existing intellectual property.

5.4.2 Ratio of new to franchise-based games

In addition to releasing fewer titles, publishers are also releasing fewer games that are not reliant on existing intellectual property. In 2018, only 13% of the games released by the eight publishers were "new," a rebound from the low of 8% in 2013. The decline in these new titles versus the overall annual game catalog is shown in Figure 5-2.

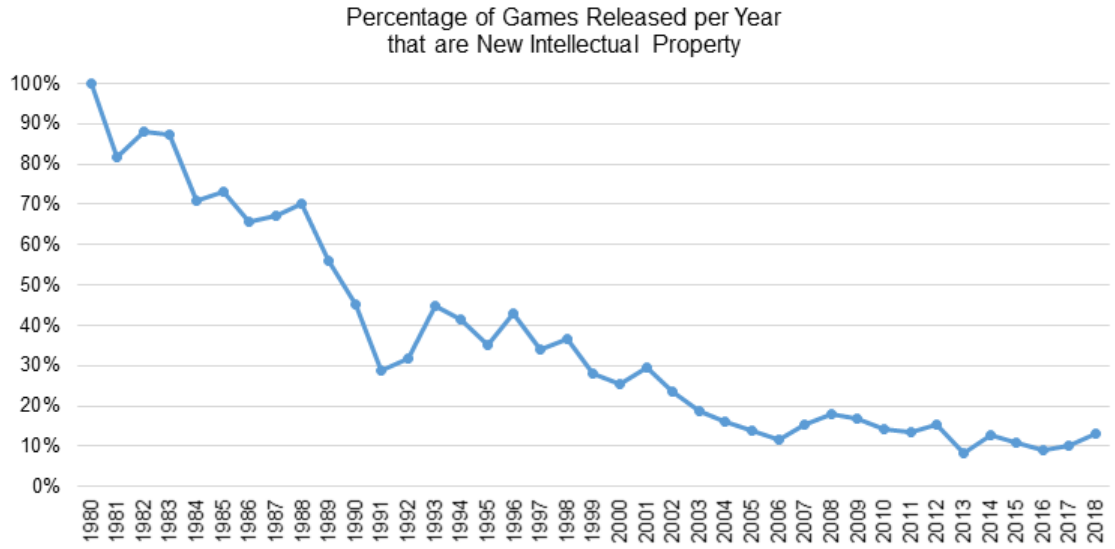

Figure 5-2. The annual ratio of games introducing new intellectual property versus games reliant on existing intellectual property for the period from 1980 to 2018.

This is further broken down by publisher in Figure 5-3, which shows the downward trend in new titles across publishers, including the two bankrupt publishers, *Midway* and *THQ*, and minimum as well as maximum values with linear trend lines fitted to the lowest and highest ratios of all publishers for each year.

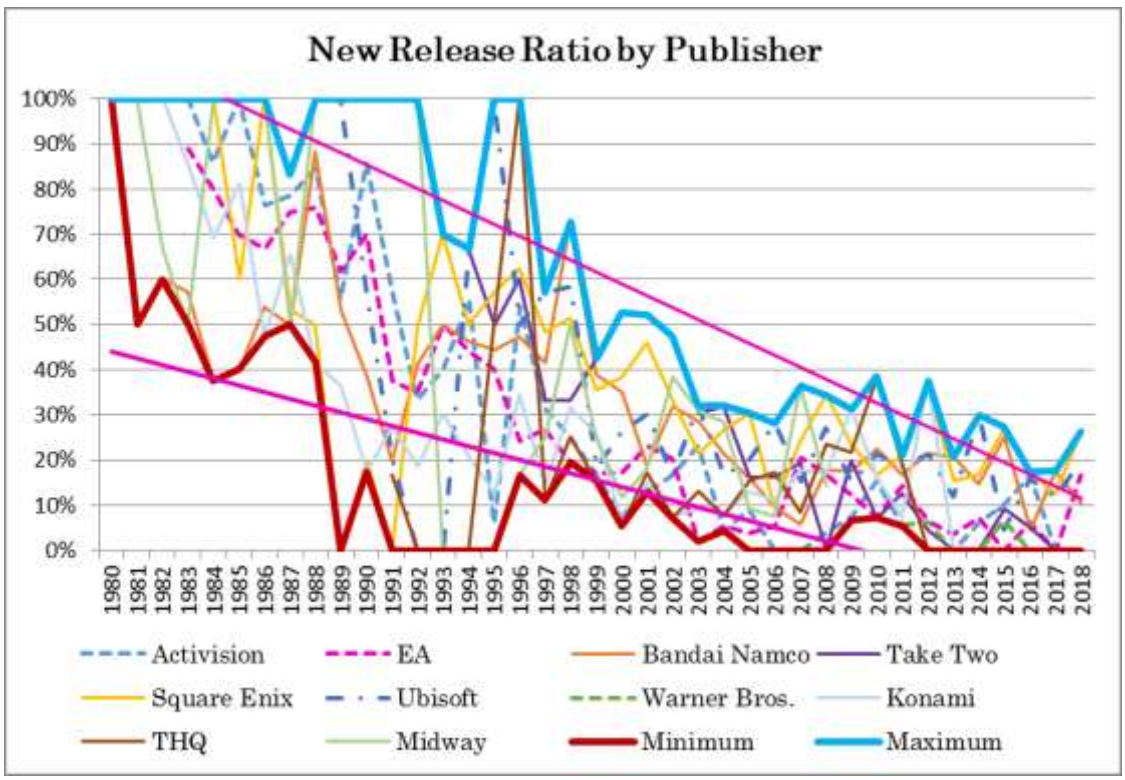

Figure 5-3. The annual ratio of games introducing new intellectual property versus games reliant on existing intellectual property for the period from 1980 to 2018, broken down by publisher. Linear trend lines were fitted to the lowest and highest ratios of all of the publishers for each year, and minimum and maximum lines indicate the highest and lowest ratios per year.

Midway began producing mostly original titles and slowly reduced that ratio until it fell in line with the average, while *THQ* began producing mostly titles based on existing IP before experimenting with original titles and falling in line with the average before their bankruptcy in 2012. Only *Square Enix* (26%) and *Ubisoft* (20%) had more than 20% of their releases as new intellectual properties in 2018; however *Square Enix* only had 13% and *Ubisoft* 12% the prior year (2017) pushing the average up in 2018 along with *Electronic Arts (EA)*, which went from 0% in 2017 to 17% in 2018. A more detailed breakdown by publisher and year is included in Table A-1 in 202Appendix A.

Of the 6,222 titles in the publisher catalog from 1980 to 2018, 1,560 (25%) were not based on existing intellectual property – whether as a sequel to a prior game or based on a sports, movie or other entertainment franchise. The higher number is influenced by the earlier years when most games were new franchises, and in the ten years from 2008 to 2018, only 291 of 2027 (14%) games were not based on existing intellectual property.

5.4.3 Franchise trends with top-ten selling games

The list of top-ten selling games from the period 2001 to 2018 was inspected for sequels and non-game and non-sport intellectual property-based franchises. The complete list of games used for the top-ten calculations is included in Table A-2 in Appendix A. Of the 150 unique games represented, only 10 (*Halo* in 2002, *Gears of War* in 2006, *Wii Play* and *Assassin's Creed* in 2007, *Wii Fit* in 2008, *Minecraft* in 2013, *Destiny* and *Watch Dogs* in 2014, *Overwatch* in 2016, and *PlayerUnknown's Battlegrounds* in 2017) were games not reliant on existing brands or intellectual properties. Although developing a new hit is important for driving growth, the top-ten lists indicate that it is more likely a major hit will be based on an existing intellectual property. None of the games that made the top-ten sales list in 2018 were new franchises.

5.4.4 Franchise age

The NPD Group's best-selling games of the year lists were analyzed for average franchise age in the top-ten best-selling games, or "hits," per year. (Figure 5-4). By 2017, the average age of game franchises represented in the top ten had climbed to 19 years old before falling to 15 years old in 2018. In particular, *Nintendo*'s *Mario* and *Zelda* franchises had a strong influence on this number, as both games received new releases in 2017. However, even in 2018, which had no *Mario* or *Zelda* releases, the average franchise age was 15 years old. Although the franchises represented in the top-ten lists have, to some extent, changed over time, the growth in franchise age provides another view on the reduction in the development of new franchises in the eight publishers in the sample.

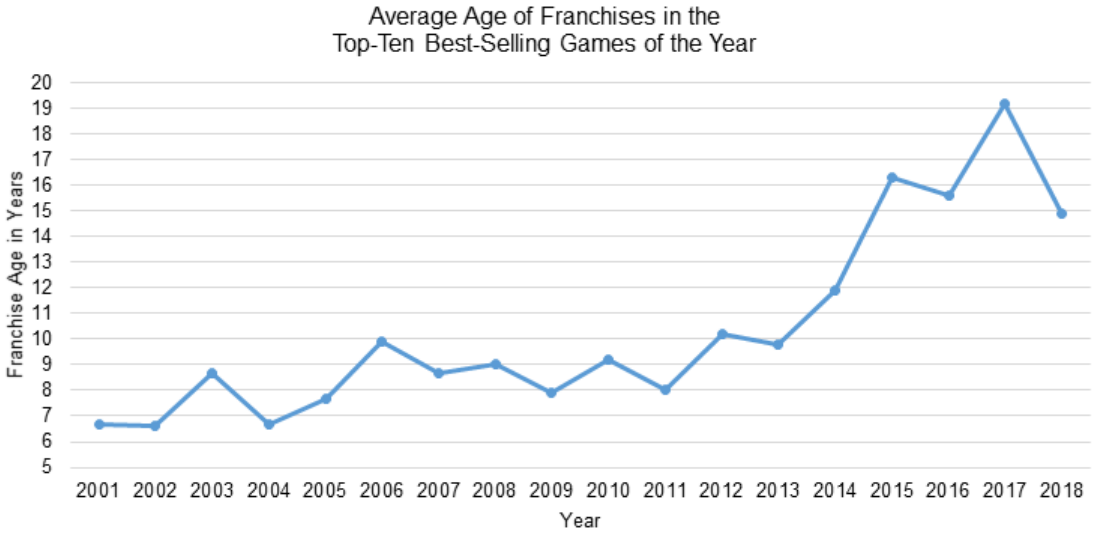

Figure 5-4. The yearly average age of video game franchises in *The NPD Group*'s annual top-ten best-selling games lists from 2001 to 2018.

5.4.5 Critical ratings for original and existing intellectual properties

To determine whether the use of existing franchises was connected to a trend in critic ratings, *Metacritic* scores were averaged by publisher for original intellectual properties, sequels, and games based on non-game and non-sport intellectual properties for games from the year 2000 to 2018. (Table 5-2) Although games based on non-game and non-sport intellectual properties, such as movie or book licenses, are below-average critically (M = 62%), games based on prior game intellectual properties are higher than the average (M = 73%), while "new" games are below average (M = 68%). The highest

rated games tend to be sequels of prior games, and few of the games in the top-ten best-selling game lists rely on a non-game, non-sport intellectual property.

Table 5-2. The average *Metacritic* scores for the eight publishers in the sample for the period from 2000 to 2018 and in aggregate, including a breakdown for games based on prior intellectual properties, games based on non-game and non-sport properties, games based on prior game properties, and games that are new properties. The same calculations were made for the two publishers, *Midway* and *THQ*, which went bankrupt during the period examined, but they are not included in the overall calculations.

Publisher	Overall Mean Rating	Prior IP Base		New IP Mean Rating
		Mean Rating	Non-Game/Sport IP	Game IP
Activision Blizzard	69%	69%	63%	74%	69%
Electronic Arts	76%	76%	66%	77%	77%
Bandai Namco	67%	67%	62%	71%	67%
TakeTwo Interactive	71%	72%	58%	74%	69%
Square Enix	73%	74%	70%	75%	68%
Ubisoft	68%	69%	60%	71%	64%
Warner Bros Interactive	71%	71%	NA	NA	78%
Konami	67%	68%	60%	71%	59%
Overall	70%	71%	62%	73%	68%
Midway (2000 – 2008)	65%	65%	55%	67%	63%
THQ (2000 – 2012)	66%	66%	59%	72%	67%

5.4.6 Revenues for game publishers in the sample

The results of current exploitation and exploration strategies on the revenues of publishers in the sample was tracked using revenues reported in publisher annual reports from 2000 to 2017. (Figure 5-5) Only five of the eight publishers were compared, because game revenues for three: *Bandai Namco*, *Warner Bros Interactive*, and *Konami*, were unsuitable for direct comparison as their businesses extend beyond games.

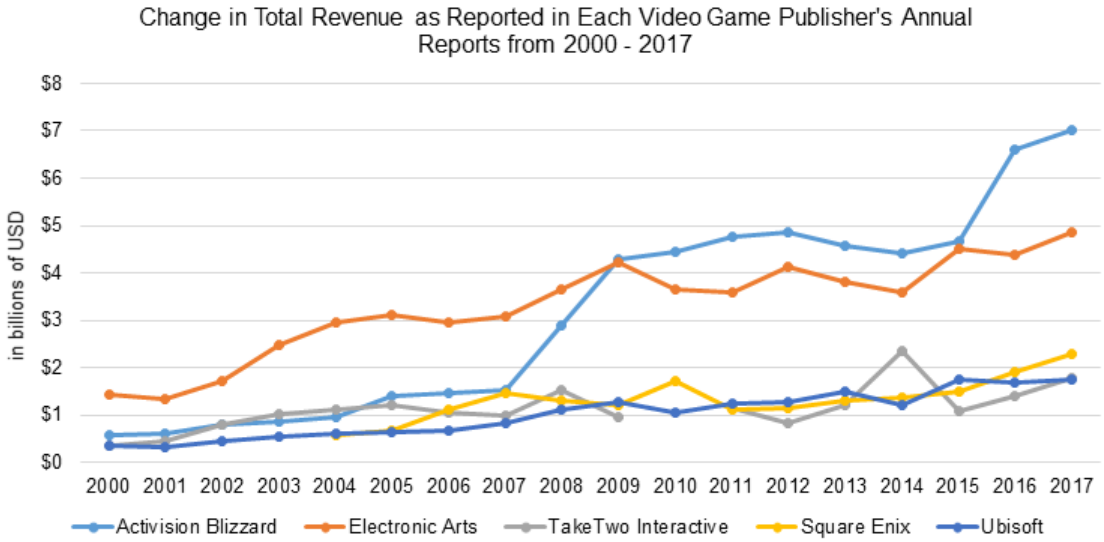

Figure 5-5. Annual revenues for five of the video game publishers in the sample in the period from 2000 – 2017.

In the case that changing development costs could have an impact on rising revenues, gross profits were also taken from the five publishers' annual reports but confirm the same upward trend. (Figure 5-6)

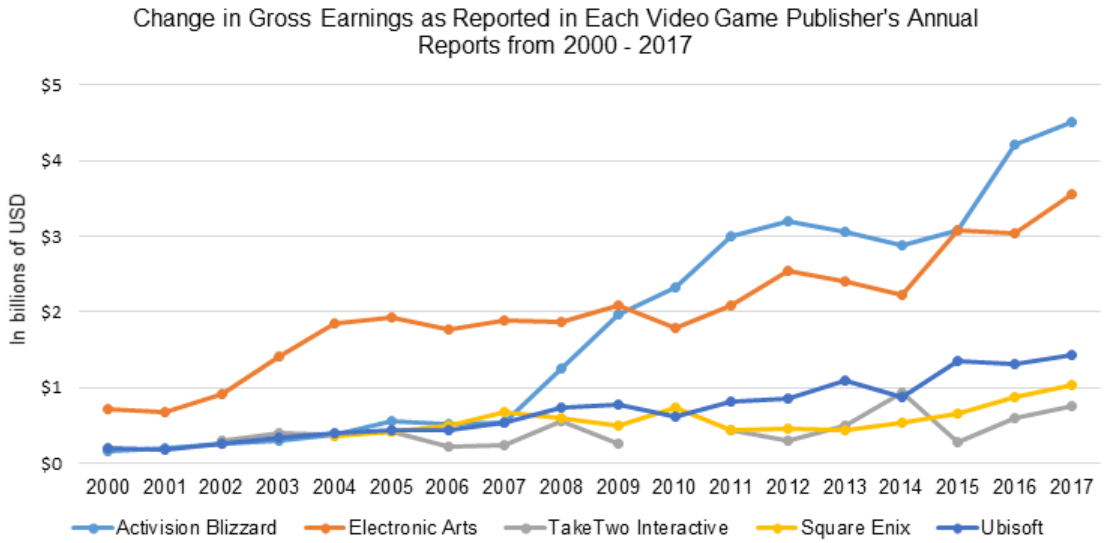

Figure 5-6. Annual gross earnings for five of the video game publishers in the sample in the period from 2000 – 2017.

At least for five of the eight publishers in the sample, both revenues and gross profits are rising, which seems to indicate that their strategy of focusing on exploiting

existing video game franchises is rewarding for the period observed.

5.4.7 Franchise series growth and critical trends

We calculated the growth volatility trends for representative, long-running video game franchises from the eight still-existing publishers in the sample through 2017. (Figure 5-7) Each iteration's sales numbers, in units, was compared to the prior entry in the series to generate the percentages. Most of the growth potential is contained within the first iterations of an intellectual property, and none of the properties obtained growth over 100% after eight iterations. Over the number of releases, the growth fluctuation pattern tends to settle. As with other risk-driven investments, such as stock investments, risk and volatility are a double-edged sword. The negative aspect of risk and volatility is that what succeeded in the past may fail; however, the positive aspect of risk and volatility is that the potential for success or growth is present. In the extreme case, if a video game organization's portfolio consists entirely of later iterations of prior game franchises, the expected result is a consistency in revenues coupled with a downward trend in profits as the costs of development continue to rise.

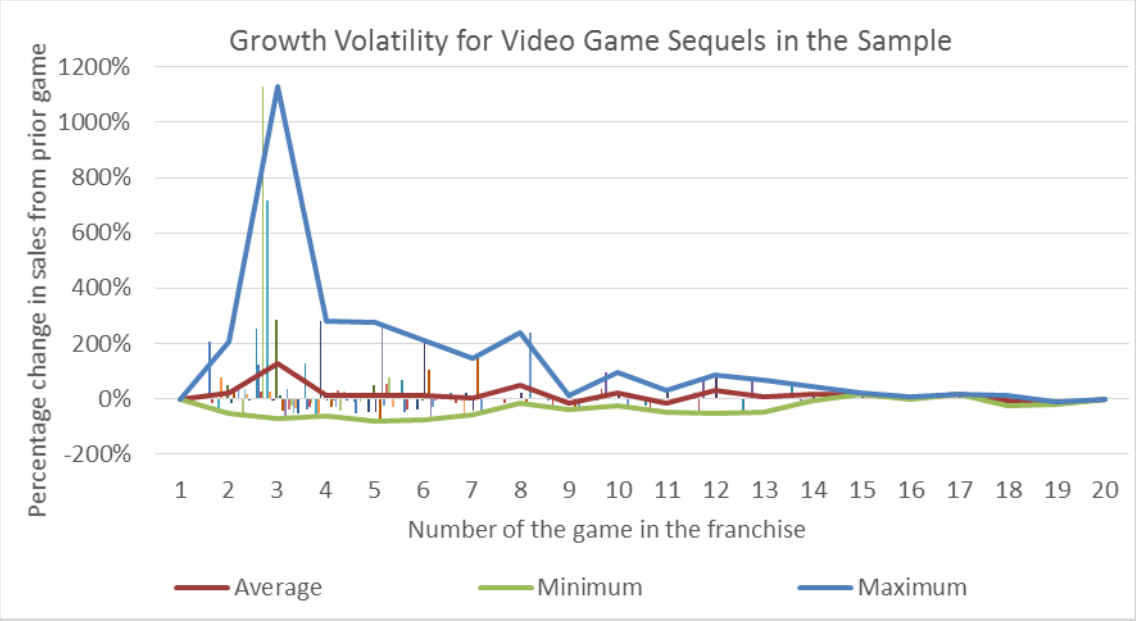

Figure 5-7. Unit sales growth volatility trends over the course of representative IP franchise series games from different video game publishers. Percentages are based on follow-up performance to the prior game in the series. The minimum, maximum, and average change in sales across the sample are indicated by bold lines.

Growth is critical to maintaining a franchise given the rising cost of development. For a specific example, the size of the original *Call of Duty* development team, excluding business and support roles, was 42 members based on the staff list, while the size of the *Call of Duty: WWII* development team who created the 2017 title exceeded 500 members. Although the series has experienced high growth from its original release, the sales growth peaked with *Call of Duty: Modern Warfare 3* in 2011 and has since declined and grown flat. Despite sales of more than $500 million in the first week, the lack of growth with the most recent entry, *Call of Duty: Black Ops 4* had a negative impact on publisher *Activision Blizzard*'s stock price. (Kim, 2018)

In addition to sales, critical reception tends to peak within the first few iterations of a series. For games in the sample with *Metacritic* scores available from the original, we analyzed where the series "peaked" and found that more than half of the games in the sample peak with the second iteration (8 out of 14). The second most common peak is with the first game (3 out of 14). *Metacritic* score volatility, like sales growth volatility tends to settle early in the series. (Figure 5-8)

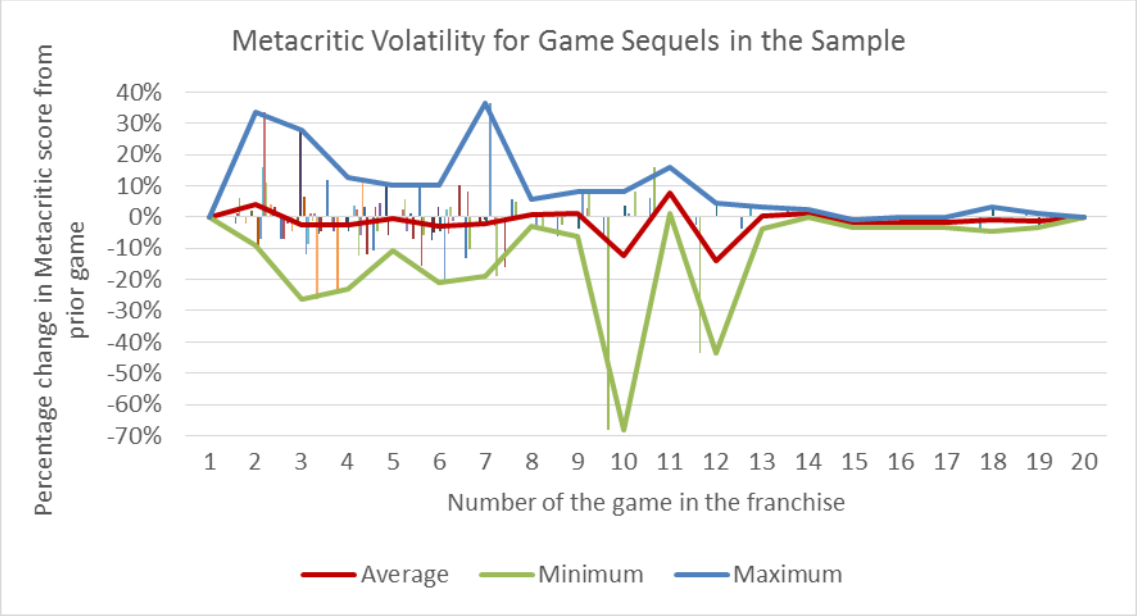

Figure 5-8. *Metacritic* score volatility trends over the course of representative IP franchise series games from different video game publishers. Percentages are based on follow-up *Metacritic* scores compared to the prior game in the series. The minimum, maximum, and average change in sales across the sample are indicated by bold lines.

The largest positive growth peak after the first three games of 37% is from the *Tomb Raider* series, which was "rebooted" with the game responsible for the positive

score, *Legend* (*Metacritic* score = 82%) after the series reached a low point with *Angel of Darkness* (*Metacritic* score = 52%). The fluctuation around the 11th game in the series is influenced by *Tony Hawk*, where the 11th game, *Shred* (*Metacritic* score = 56%), was released between two lower scoring games, Ride (*Metacritic* score = 47%) and *Pro Skater 5* (*Metacritic* score = 39%) – the end of the franchise. The detailed breakdown of games used for growth and critical trends is included in Table A-3 and Table A-4 in Appendix A.

5.5 Exploration and Exploitation Trends in Video Game Publishing are Shifting over Time

Through a quantitative analysis of 6,222 games produced by 10 third-party console and PC game publishers from 1980 to 2018, we have analyzed the trend shift in exploration and exploitation strategies and can verify our hypotheses.

5.5.1 Third-party game publishers are growing more conservative

- H1: Large third-party video game publishers are growing more conservative, producing fewer games and more games based on existing intellectual property

Top publishers are producing fewer games – around a third (98) the number being released ten years prior (290) for the eight publishers in the sample. Simultaneously, fewer investments are being made in exploring new intellectual properties. From the 100% original intellectual property ratio in 1980, the beginning of the survey, the ratio of "new" games versus games based on an existing intellectual property has continued to fall – reaching less than half (45%) in 1990 and down to 13% in 2018 after a rebound from the low of 8% in 2013. Also, only *Square Enix* (26%) and *Ubisoft* (20%) had more than 20% of their releases as new intellectual properties in 2018, and it is worth noting that only 13% and 12% of their catalog in 2017 were new titles.

At least for the publishers in the sample, there is a trend that they are producing fewer games and relying more on games based on existing intellectual property franchises, verifying our first hypothesis.

5.5.2 An exploitation strategy is being rewarded and reinforced

- H2: The intellectual property exploitation strategy in video game publishing is being rewarded and reinforced through sales and critical response.

The revenues of the publishers in the sample relying on sequels and existing intellectual property franchises are rising. For the five publishers in the sample relying on their video game businesses, all five (*Activision Blizzard*, *Electronic Arts*, *Take Two Interactive*, *Square Enix*, and *Ubisoft*) have grown revenues and profits in the 18 years measured, from 2000 to 2017.

Few "new" games are found in the top-ten best-selling game lists – only 10 of the 150 games in the top-ten best-selling games lists from 2001 to 2018 were not based on an existing intellectual property franchise. In 2018, none of the games in the top-ten best-selling list were new franchises, and the only "new", non-sequel game was based on *Marvel*'s *Spider-Man* franchise. The franchises relied on for "hits" making the top-ten lists are growing older, with an average age of 15 years old in 2018. If the goal is unit sales, relying on an existing franchise seems an appropriate strategy. Despite the desire for new experiences, consumers do seem to prefer "accessible" and "familiar novelty" (Lampel et al., 2000). In a market where a product needs to be experienced to determine its value and some risk of being unsatisfied by a purchase is involved, a sequel signals that the quality is related to that of the prior experience, in the case where the consumer has experienced a previous game in the series, or that the quality is high enough to warrant a sequel, in the case where the consumer has not experienced the prior game. According to research by Situmeang, Leenders, and Wijnberg, in cases where the prior games reviewed well, those evaluations could influence sequel success. (Situmeang et al., 2014)

In addition to sales, the average critical *Metacritic* scores are higher for franchise-based games, with the caveat that this only applies to sequels to prior video games, not games based on other intellectual property franchises. For the publishers in the sample and games released from 2000 to 2018, the mean *Metacritic* score was 73% for game sequels versus 68% for "new" games not based on an existing intellectual property. This difference is significant, because 73% is close to the 75% cut-off *Metacritic* has determined for a "favorable" rating and close to the highest average rating of *Electronic Arts*, 76%, for the publishers in this sample. On the other side, 68%

is near the bottom range of the publisher *Metacritic* averages (67%), and just above the 65% and 66% average of the publishers, *THQ* and *Midway*, that went bankrupt.

The results of this research reinforce the hypothesis that an exploitation strategy is being reinforced and rewarded through sales and critical response.

5.5.3 A limit exists in the exploitation strategy

- H3: Large video game publisher reliance on an intellectual property exploitation strategy sets a limit to growth potential as later sequels are less likely to attract new players or create new markets.

Our analysis found that there are sales and critical growth limitations to relying on an exploitation strategy. Although unit sales and *Metacritic* ratings are higher, on average, for video game franchise sequels than for "new" games, fluctuation in franchise growth stabilizes over the number of iterations in the series. *Metacritic* score volatility also stabilizes within the first few iterations, with positive volatility exceptions, such as *Tomb Raider*, being due to the "rebooting" of a series with falling scores. In addition to volatility, the majority (11 out of 14) of the critical scores for games in the sample peaked with the first (3 out of 14) and second iteration (8 out of 14).

While this does mean revenue and critical response are more predictable, it also places publishers in a dilemma as stale growth is not enough to support rising development costs or demands for corporate growth. Considering growing development budgets, stale growth means less profit with each sequel and could lead to an eventual decline in market share as Ikuine (2006) discovered with the Japanese video game market in the late 1990s as a result over over-exploitation of video game sequels.

THQ is one example of a publisher that pursued an intellectual property exploitation strategy that fell through; despite a later shift to original content, profits from formerly "safe" licensed content dried up, and, when combined with other problems, led to the end of the publisher. (Lien, 2014)

Although, overall, revenues for the publishers in the sample are rising, we have shown that there are growth limitations to relying on an exploitation strategy, with a long-term downward trend in sales.

5.5.4 Limitations to the data analysis

We acknowledge several limitations to this research. First, is the limitation that the research focuses on console and PC game publishing, ignoring mobile or web-based game publishing – a significant source of the businesses in *Newzoo*'s list of top 25 publishers by revenue. Also, we have focused only on third-party video game publishers, ignoring the exploration-exploitation strategies of publishers with a hardware platform, such as *Nintendo*, *Sony*, or *Microsoft*. Finally, by analyzing the top publishers, with the reasoning that the top 25 publishers represent 77% of the industry's revenue, we ignore the mid-tier publishers, who may possess different innovation strategies that have evolved differently over time.

Another limitation to this research is that it does not explore the extent of the risk associated with the development of "new" game franchises and how that could be changing. For purposes of analyzing the overall trend over time, we have categorized games not based on a prior intellectual property franchise as being part of an exploration strategy; however, there are degrees to how much "exploration" is occurring. Games considered "new" for the purposes of this research could be argued to be part of an exploitation strategy if they are relying on similar game designs to past hits from "proven" development teams, or the publishing of independent games that have already demonstrated some degree of success.

Also, this research does not cover the acquisition strategy of publishers, who could rely on acquisitions of smaller publishers or developers who have done the risky work of "exploring" a new game franchise. This strategy could allow them to compensate for an exploitation strategy by letting others take the early risks of an exploration strategy.

5.6 Video Game Publishers Increasingly Rely on an Exploitation Strategy as Development Costs Rise

Firms in all industries tend to emphasize exploitation at the expense of exploration because the results of exploration are unpredictable and exploitation is more attractive for short-term returns even if it means not pursuing better alternatives. (Denrell and March, 2001) As development costs rise and the number of projects fall, exploiting existing intellectual property franchises is a rational strategy for hedging against the growing fiscal consequences of failure. In prior research, Tschang (2007)

explored the rationalization process that occurs within video game publishers trying to control risks in an uncertain industry with complex entertainment products. Through our quantitative survey covering 6,222 games from 1980 to 2018, we found that the top third-party console and PC game publishers are increasingly pursuing an exploitation strategy, producing fewer games and even fewer "new" games every year. As of 2018, only 13% of games are "new."

This exploitation strategy is being rewarded, as top publisher revenues continue to grow while they limit risky investments in new franchise development. Most games in the top-ten best-selling lists are sequels to existing franchises or based on intellectual property licenses from outside the video game industry. Critical reception also appears to favor an exploitation strategy. *Metacritic* scores are higher on average for existing franchises than for new intellectual properties, with the caveat that scores are lower on average for games based on non-game and non-sport properties. This does lend support to Lampel et al.'s (2000) observation that consumers want "familiar" innovation. Whether through sales or critic ratings, publishers are being rewarded for pursuing an exploitation strategy and the ratio of new to franchise games seems to reflect this.

However, sales growth within a franchise tends to peak early and then fall over time, and new franchises are required to replace flagging, older franchises if a video game company is to continue to grow. There is a need to perform exploration activities to "renew" the intellectual properties available for development. (Parmentier and Picq, 2016) This is the fundamental problem with a pure exploitation strategy. Some exploration is required to provide for future growth; however, development costs make investing in new franchises risky. An exploitation strategy is no guarantee for survival; both *THQ* and *Midway* pursued a similar balance to that of the other eight publishers sampled towards the end of their lifetimes. Although it is easy to focus on individual video game projects and the higher likelihood that a game exploring new intellectual property will fail from a business perspective, failure is the price of uncertainty, and a strong portfolio strategy could reframe exploration activities as "intelligent failures" and view failure as a part of a necessary experimentation process. (Edmonson, 2012) Such experimentation could be required for a business to continue to grow in the long-term. Ikuine's (2006) research demonstrated how an over-reliance on IP exploitation harmed the Japanese video game industry in the 1990s, so there is a risk that such strategies could eventually cost top publishers their current dominance.

Rising development costs will continue to push publishers to relying on an exploitation strategy; however, limits to growth imply that they must find ways to supplement these short-term "winning" strategies with long-term exploration strategies

or risk stagnation and poor business consequences.

5.7 Utilizing KDD with External Data to Verify Decisions Regarding Intellectual Property Exploration and Exploitation in the Video Game Industry

The research presented in this chapter employed KDD techniques to quantify trends in intellectual property exploration and exploitation within the eight largest third-party publishers of PC and console video games and two large third-party publishers that went out of business during the period surveyed to answer the question:

- What is the state of intellectual property exploitation and exploration strategies in innovation and business management practices within leading video game organizations and how are those strategies changing?

Given rising development costs, video game organizations only have a limited number of projects they can run at any time. With limited project budget resources, they must attempt to maximize the potential for generating hits and obtaining profits from the games they choose to develop. The benefits of the knowledge gained through employing a KDD technique such as the one presented to decision-makers deciding between whether to increase the likelihood of creating a new "hit" while accepting greater exposure to risk and volatility with exploring new IP franchises or to take advantage of production efficiencies and hedge risk by exploiting proven IP franchises is the ability to actively question tacitly held assumptions regarding the amount of risk that is appropriate for the organization given the innovation strategies of its competitors and the overall industry. (Figure 5-9)

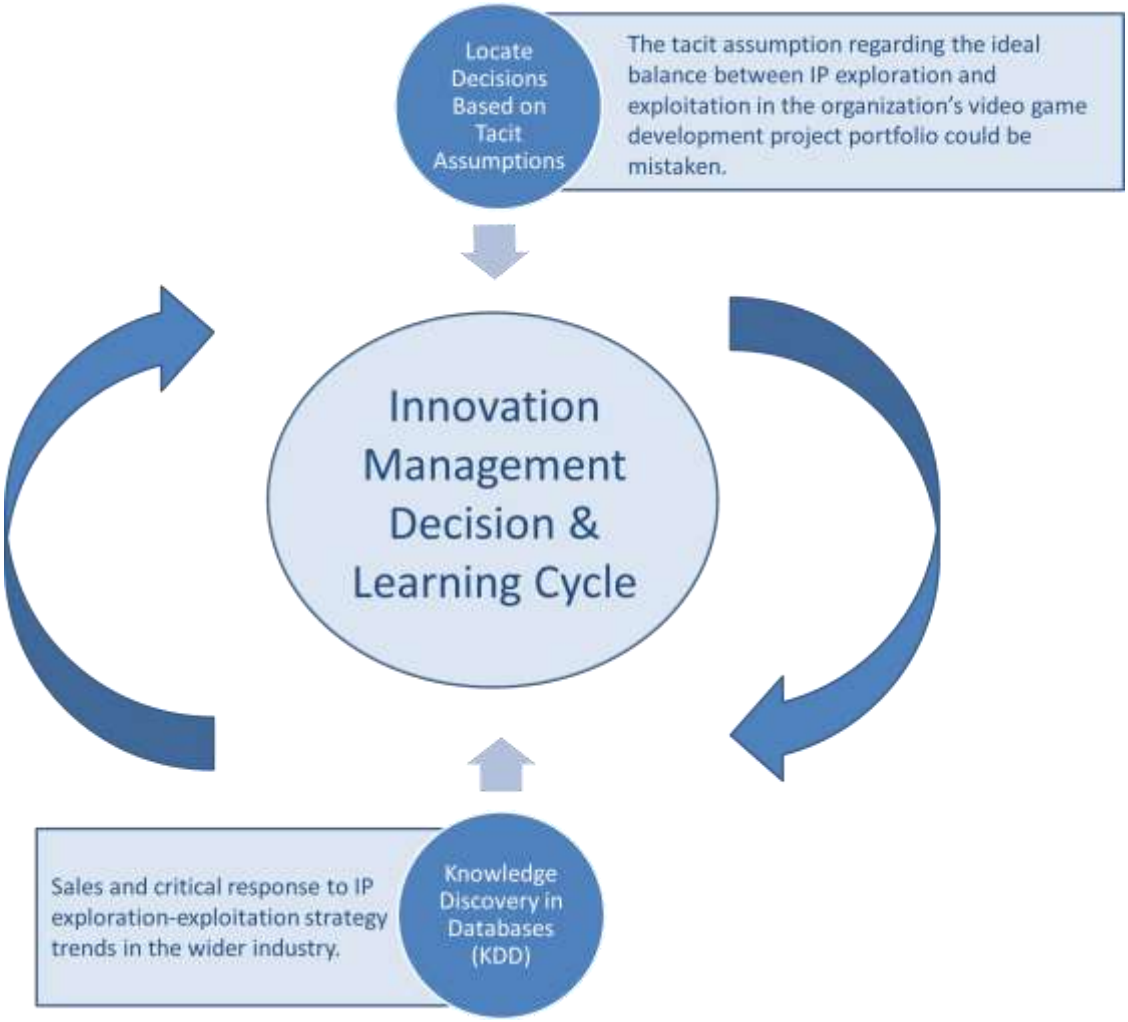

Figure 5-9. Incorporating industry-wide data to validate or position assumptions regarding exploitation-exploration strategies in intellectual property (IP) development in video game organizations.

6. Analyzing the Gender Diversity of Video Game Project Owners

In Chapter 6, I explore the extent of gender diversity among video game developers, with a focus on positions with creative voice, such as directors and producers. The research provides an answer to the question:

- What role do women play in making creative decisions within video game development organizations and how does this compare to video game consumer demographics?

The ratio of female game consumers to men is growing. Based on *Entertainment Software Association* (ESA) surveys of the U.S. video game market, the percentage of gamers identifying as female has risen from 38% in 2006 to 46% in 2019. (Gough, 2019) Cultural diversity has been found to have a positive effect on the creative process in video game development (Scholz, 2012), and there is a "positive relation between gender diversity and the likelihood that firms innovate." (Østergaard et al., 2011) Diversity is an important requirement for innovation and challenging assumptions. (Cohen and Levinthal, 1990) Low diversity among video game project owners could result in fewer challenges to assumptions and lead to a higher level of conservatism. In particular, women are known to be underrepresented in video game development. (Williams et al., 2009) However, women in video game development face issues such as the pay disparity reported at *Rockstar North* and the "bro culture" issues reported within *Riot Games*. Some development roles are rewarded more, whether by pay or creative voice, than others. Although there has been research into gender disparity by roles within other entertainment industries, such as the movie industry, there has yet to be a data-based examination of gender disparity broken down by role within the video game industry.

To provide a more nuanced examination of the gender gap that exists in game development, I analyze the gender and roles for 14,265 staff listed in the credits of 27 games produced by seven of the video game publishers most represented in top-ten best-selling game lists to discover how the distribution of women and men varies by role. I also analyze the gender of producer and director roles in all of the top-ten best-selling games from 2001 to 2017 to provide a wider view of representation in creative

leadership in the "AAA" game development space. Other analyses include visualizing the relative position of women in staff credit lists, women in executive leadership in the top 25 game companies by revenue, and representation of women in video game conferences such as the *Game Developers Conference* (*GDC*) and the *Computer Entertainment Developers Conference* (*CEDEC*).

6.1 Gender Diversity in Video Games and Development

Although the 2019 *Entertainment Software Association* report identified 46% of gamers as being female (Entertainment Software Association, 2019), the kinds of console and PC games that are given the budgetary support to reach top-selling "AAA" status still attract mostly men. Yee's (2017) survey of 270,000 gamers about the types of game genres they enjoy playing found that the ratio of women falls for traditional AAA genres such as "sports" (2%), "tactical shooter" (4%), "first-person shooter" (7%), "action-adventure" (18%), "sandbox" (18%), and "action RPG" (20%).

Publishers are aware of this; few of the top-selling games feature women as game characters at all, let alone in the lead role. Williams et al. (2009) performed a survey of video game characters in top-selling games released between 2005 – 2006 and found that only 15% of game characters were female and only 10% of primary game characters were female. They also suggested the low ratio could reflect the demographics of game developers. In a 2017 *International Game Developers Association* (*IGDA*) survey, only one in five developers who responded were women. (Weststar et al., 2018) There is also the false stereotype of the "male gamer" that leads the female gamer audience marginalized and underserved. (Paaßen et al., 2017) Attempts to target games at a female audience have not met with much success, as there is a question of "whose notion of 'female' is being portrayed in the game." (Dickey, 2006) Existing ideas regarding market segmentations and the identity of consumers generates an "industry lore" regarding preferences that guides gatekeepers' decision-making. (Havens, 2007) Production workers also tend to "narrow the range of creative ideas that they propose" in response to the preferences of their superiors "in ways that maintain the hegemony of particular textual forms and ideologies in cultural industries." (Draper, 2014) In other words, the ideologies of the employees with power and creative voice shape the products being produced, so it is important to examine who is filling those roles and question whether that represents the potential consumer audience.

6.1.1 Issues faced by women in video game development

There continue to be reports that women face a hostile environment in video games, both as players and developers. Posts with the #1ReasonWhy hashtag on *Twitter* show that the problems faced by women in game development are numerous. In 2017, *Grand Theft Auto* developer *Rockstar Games* and *League of Legends* developer *Riot Games* both came under the spotlight for their employment practices.

While women comprise around 20% of the employees at *League of Legends* developer *Riot Games*, some interviewed reported a sexist "bro culture" where women are talked over and kept out of leadership roles. (D'Anastasio, 2018) D'Anastasio also reported that, within *Riot*'s top management team, 21 out of the 23 roles are filled by men. Gender discrimination issues like these have led to a class action lawsuit against *Riot Games* by one former and one current employee. (2018) Gender disparity is not only a problem for AAA games and large publishers. Kiley (2016) showed that in the independent game development scene, few *Independent Games Festival* (*IGF*) award winners are women. At the time of Kiley's research, only one woman in 2006, a member of a husband and wife team, was represented in the *Audience Award*. When we verified the list of *IGF* award winners, the only woman involved in the creative direction for a winner of the largest prize, the *Seumas McNally Grand Prize* worth $30,000, was the co-designer on *Night in the Woods* in 2018.

Women also earn less in the video game industry. Of the developers surveyed in the *Gamasutra* salary survey released in 2014, men earned an average of $85,074 in 2013, while women earned only $72,882. (2014) At *Grand Theft Auto* developer *Rockstar North*, the UK's Gender Pay Gap database revealed that women working there earn a mean of 36% that of men. (Gov.uk, 2017) Although this statistic does not necessarily mean that women in the same role are being paid less, the same report noted that only 8% of the top quartile of earners are women. These statistics do indicate that, at the very least, women are not represented in well paid roles.

Developers are being forced to recognize the problem. *Riot Games* has pledged to take steps to correct the reported issues, and companies like *Nintendo* are publishing their employee gender diversity statistics (Nintendo, 2018) in an attempt to make the gender gap more transparent. However, as the *Rockstar North* gender wage gap shows, the ratio of men to women is not the only important factor that needs to be considered. Two important factors leading to a wage gap are the difference in pay for equal work and the opportunities available for higher paying positions. Our research focuses on the latter issue by exploring the representation of women in higher paying and leadership roles within the video game industry.

6.1.2 Differences in gender representation by roles

Prior research into the IT and movie industry has discovered gaps both in the representation of women overall and in leadership roles. Rangarajan (2018) analyzed the results of an anonymous survey of 177 Silicon-valley tech companies and found that the representation of women, particularly women of color, falls with each level up the ladder – from professional to manager to executive. The survey results showed that white men account for 39% of professional roles, 47% of managerial roles, and 59% of executive roles. Rangarajan also found that, even in diverse companies, women were overrepresented in support roles. In the movie industry, Smith et al. (2018) analyzed the staff involved in 1,100 movie productions and found only 4% (53) of the 1,223 directors were women.

Within the video game industry, the top earning staff-level roles are concentrated in sound and programming fields (Gamasutra, 2014); however, these two fields are both known to be underrepresented. Using *Bureau of Labor* statistics, Ashcraft et al. (2016) reported that only one in four computing occupation roles were filled by women. In the same report they pointed out that women in these roles left in greater numbers than men because they found fewer opportunities for training and development, received less support from managers, and did not receive enough support for balancing work with competing responsibilities. Mathew et al. (2016) pointed out that only 15% of audio engineers are women and noted that women in audio face "bro cultures", "mansplaining", questioning of their skill, unequal treatment, and sexism.

Much like the film industry, there are few women in the highest profile creative roles within the video game industry. Media site *IGN*s top 100 game creators list features 104 men and only 2 women: Danielle Bunten Berry (#92) and Roberta Williams (#23), who shares the spot with Ken Williams. (IGN, 2009) Gender diversity is more than a corporate social responsibility, it is critical for the video game industry if it wants to make games that serve its players. Through this research, we explore gender diversity in video game development teams by role and in leadership positions. In addition to game development staff, we examine the gender of board of director members for the top 25 publishers by revenue, with a focus on the gender ratios of "insiders" involved in daily decision making.

6.2 A Data-Based Approach to Exploring Representation

We have taken a data-based approach to investigating the representation of women in the video game industry. We analyze the gender and role of 14,265 staff listed

in credits for 27 representative video games produced by seven of the console game publishers most represented in *The NPD Group*'s top-ten best-selling game lists. In some cases, the games we have chosen represent a series of games in a publisher's intellectual property franchise to provide some insight into how trends could be changing over time. We focus our analysis on the most recent video game in the series (7 of the 27 games sampled) to capture the current video game industry, but we have included data on prior games in the series to show how the overall gender gap has changed.

We chose video game information aggregation site *MobyGames* as the source of staff lists for the selected games. Lists of the top-ten best-selling games for each year from 2001 to 2017 were obtained from data released by market research company, *The NPD Group*. Members of video game company boards of directors were gathered from the annual reports released by publishers and official corporate sites for the top 25 game publishers by revenue according to *Newzoo*. (Wijman, 2018)

This research focuses on the staffing in representative intellectual property franchises for seven console video game publishers: *Activision Blizzard*, *Electronic Arts*, *Nintendo*, *Take Two Interactive*, *Ubisoft, Microsoft, and Square Enix*. We chose these publishers because they had the most games (90%) in *The NPD Group*'s top-ten best-selling games by revenue lists for the period from 2001 to 2017. Our selection of a "representative" franchise for each publisher was based on several factors: games with multiple entries in the top-ten best-selling game lists, franchises comprised of games with publicly available staff lists, and franchises which made the top-ten lists across the period examined were chosen. To keep the comparisons over a series as direct as possible, we have not included franchise spin-offs, such as *Mario Kart*, because the differing nature of the games will affect the composition of the team required to create them. For the same reason, we have also focused only on main entries, such as *Final Fantasy XV* from *Square Enix*, rather than downloadable content (DLC) or expansions to Massively Multiplayer Online (MMO) content.

Although the top-ten best-selling game lists from 2001 to 2017 served as our source for the selection of games in the sample, we have included staff list data for games in the representative series prior to 2001. We did this to show how the gender ratios for developers on the series have changed over the course of the series. In *Nintendo*'s case, we selected the *Super Mario Bros.* platforming series as the representative franchise but have also included the game *Wii Fit* because it targeted a unique demographic compared to other titles in the top-ten lists. In *Microsoft*'s case, we selected *Halo* as the representative franchise but have also included staffing data for

Minecraft because of its unique position as an independent title in the top-ten best-selling game lists. We decided to focus on top-selling games from large publishers because they are the games that receive the most attention and the largest concentration of revenue. According to *Newzoo*, the top 25 publishers control 77% of the global games market (Wijman, 2018), which implies they are in the best position to reward their staff.

Video game consoles have been a market for more than 40 years, making them a comparatively stable source for comparison compared to other, newer video game markets. This is particularly useful when analyzing changes over several games in a long-running franchise series. We have not included high-revenue generating mobile or online multiplayer games, such as *League of Legends* from *Riot Games*. In addition to the stability reasons stated, the differences in the markets in which they operate, the development style and team compositions required to create them, and their relatively recent emergence as separate markets would make direct comparisons with AAA console games inappropriate.

6.2.1 Gender and role tagging

We used the site *genderize.io* to determine the gender of common first names. In cases where we could not make a reliable prediction of gender by the name alone, we searched for individuals using their names together with the game titles or the publishers producing the game. This often led to a *LinkedIn* or *Facebook* site that could be used to determine gender. If we could make a reasonable determination based on the name, we labeled the staff "male" or "female"; in other cases, we labelled the staff "undeterminable". One unfortunate and important drawback to using names to reference gender is that the method can only be used to determine biological male-female gender ratios, ignoring transgender representation. Based on the 2017 *IGDA* survey, 2% of developers responded as being male to female transgender, 1% female to male transgender, and 2% "other". (Weststar et al., 2018) If the numbers are representative of the game industry, 5% of the population will be mislabeled through a method that focuses on biological gender. Across all of the staff credits used in the research, 4% of staff gender was undeterminable through the above technique. The majority of unknowns were from development partners to whom work was outsourced; in many cases, the individuals listed did not possess a searchable professional profile.

We excluded voice actors and actresses as well as soundtrack music composers from the gender counts because they are unlikely to influence the development of the

game itself. Although they both make valuable contributions to the video game project, they tend to work independently from the video game project and are hired on a short-term contractual basis. Even if it lies outside the scope of this research, exploring voice acting gender ratios in video games could expose a similar trend to the gender discrepancy found in movie speaking roles by Smith et al. (2018), who analyzed 1,100 films and found only a third of speaking roles were filled by women.

After labeling gender, we divided the staff into categories based on the name of their credited position in the project. Unfortunately, video game crediting is not as consistent as it is in the film and television industry. This leaves each company, and sometimes each team, to decide what "roles" staff are listed with. In most cases, the general category of work implied by the position was clear, even if the naming varied by team. We tagged position names based on one of the researcher's experience in the video game industry and sorted the staff member into several sub-categories. (Table 6-1)

Table 6-1. Role separations for the staff in the sample.

Primary Function	Professional Role	Leadership Division
Development	Management	Leadership
		Non-Leadership
	Design	Leadership
		Non-Leadership
	Tech	Leadership
		Non-Leadership
	Art	Leadership
		Non-Leadership
	Sound	Leadership
		Non-Leadership
Support	Support	Leadership
		Non-Leadership

First, we determined whether staff were in either a "leadership" or a "non-leadership" position. Roles with "director", "producer", "manager", "supervisor", "lead", "chief", "senior" or similar designations were grouped into the "leadership" category. Next, we split positions into one of six professional categories: "management", including directors, producers, assistant producers, and project managers; "design", including game designers, planners, scripters, and narrative roles; "tech", including programmers and technicians; "art", including visual artists, animators, and technical

artists; "sound", including sound engineers and musicians; and "support", for roles outside of the development team, including QA, technical support, business development, marketing, and studio management. We also divided staff into a more general, binary category based on whether they worked directly on the game's components ("developer") or supported the game development ("support") to determine if the gender ratios vary based on how close staff were to the product development. For games with smaller teams, such as the original *Super Mario Bros.* or *Minecraft*, the same person was often responsible for multiple roles. In this case, we counted them once for each role, so the total number of roles do not reflect the total number of people on the team.

Smith et al.'s (2018) prior research into the film industry exposed the low ratio of women to men in directing roles, so we wanted to investigate the representation of women within creative leadership roles in video games. The people in these roles have a strong voice in determining both the target audience and the creative output of the development teams they lead. To explore the possibility that women are underrepresented in these roles within a larger sample, we examined the gender for directors and producers of every game in the top-ten best-selling lists from 2001 – 2017.

6.2.2 Staff credit ordering

In addition to divisions by role, we examined the order of the staff lists themselves to find whether men or women tended to be listed higher, because, like movies, order tends to place "more important" contributors higher in the list. To discover patterns that could remain hidden in statistical analysis, we color-coded the staff lists based on the gender of staff and the order they were listed. The focus was on women, so we color-coded staff lists with a neutral gray for men and a visibly clear red (dark gray in grayscale) for women. We labeled undetermined staff with a grayish-red (light gray in grayscale) to reflect the possibility that the undetermined staff could be women without skewing the visualization to show more women than are likely present. We decided to keep the color closer to neutral to represent the various survey results and reports that men outnumber women. To allow for easy comparison of teams, we scaled all of the visualizations to the height of the smallest team, *Super Mario Odyssey*'s 205-person team, using *Photoshop*'s bicubic resample function. We chose this function over the simpler nearest-neighbor algorithm to avoid the possibility that women in larger teams would disappear from the visualizations. The bicubic resample blends colors, so every staff member's gender affects the final visualization. Smaller teams will,

as a result, appear sharper and larger teams blurrier, but this method enables comparing multiple teams of varying sizes side-by-side.

6.3 Representation of Women in Games and Development

To reconfirm Williams et al.'s (2009) research results that women are underrepresented in game products, we checked the main characters for the top-ten best-selling games from between 2001 and 2017 and found no examples where a woman was the featured playable character. In 69% (117) of cases, men were the only playable character, and in the remaining 31% (53) of cases, gender was either unspecified or both genders were playable.

Based on the gender of 14,265 staff listed in 27 video game projects, women were, as expected based on the *IGDA* survey results, underrepresented in video game development compared to the general population. (Table 6-2)

Table 6-2. Gender ratios of the staff listed in video game credits for games in the sample.

Video Game	Publisher	Release Year	Employees Credited	Women Represented	Gender Unidentified
Battlefield 1942	Electronic Arts	2002	200	13% (25)	2% (4)
Battlefront 2	Electronic Arts	2017	2710	18% (476)	7% (179)
Super Mario Bros.	Nintendo	1983	10	0% (0)	0% (0)
Super Mario World	Nintendo	1990	16	0% (0)	0% (0)
Mario 64	Nintendo	1996	44	9% (4)	0% (0)
Super Mario Sunshine	Nintendo	2002	70	13% (9)	1% (1)
Wii Sports	Nintendo	2006	119	12% (14)	3% (3)
Super Mario Galaxy	Nintendo	2007	121	23% (28)	0% (0)
Super Mario Odyssey	Nintendo	2017	205	22% (46)	0% (0)
Call of Duty	Activision Blizzard	2003	163	13% (22)	<1% (1)
Call of Duty: Black Ops III	Activision Blizzard	2015	2,003	12% (240)	8% (155)
Grand Theft Auto	Take Two	1997	77	5% (4)	0% (0)
Grand Theft Auto III	Take Two	2001	131	10% (13)	<1% (1)
Grand Theft Auto IV	Take Two	2008	621	11% (68)	2% (14)
Grand Theft Auto V	Take Two	2013	1,113	12% (136)	3% (32)

Assassin's Creed	Ubisoft	2007	638	15% (98)	2% (10)
Assassin's Creed: Origins	Ubisoft	2017	3,291	21% (679)	5% (176)
Final Fantasy	Square Enix	1987	5	0% (0)	0% (0)
Final Fantasy VI	Square Enix	1994	49	8% (4)	0% (0)
Final Fantasy VII	Square Enix	1997	357	15% (51)	2% (7)
Final Fantasy X	Square Enix	2001	413	13% (53)	2% (10)
Final Fantasy XIII	Square Enix	2009	756	20% (146)	4% (33)
Final Fantasy XV	Square Enix	2016	369	18% (67)	2% (9)
Minecraft	Mojang / Microsoft	2011	30	3% (1)	0% (0)
Halo: Combat Evolved	Microsoft	2001	80	3% (2)	0% (0)
Halo: Reach	Microsoft	2010	392	7% (27)	<1% (3)
Halo 5	Microsoft	2015	282	6% (16)	<1% (2)

The original *Final Fantasy* and *Super Mario Bros.* and *Super Mario World* games were the least represented because they had no women on their staff when they were developed in the 1980s. However, later games in *Nintendo*'s *Super Mario Bros.* franchise, *Super Mario Galaxy* and *Super Mario Odyssey*, had the highest ratio of women to men of games in the sample at 23% and 22%. In most cases, the ratio of women working on each iteration of a video game franchise has improved over time. The *Super Mario Bros.* franchise went from having no women credited in the mid-1980s to around 10% credited in the mid-1990s to above 20% in the late 2000s onward. The *Final Fantasy* series experienced a similar climb, although it dropped below 20% with the latest (*Final Fantasy XV*) in the series.

6.3.1 Representation of women in development and support

First, to explore the makeup of the people responsible for game content, we categorized the staff of each project into either a development role (Figure 6-1), for those who worked directly on creating the product, or a support role, for those who contributed to the final product through areas such as quality control, marketing, or studio management. (Figure 6-2)

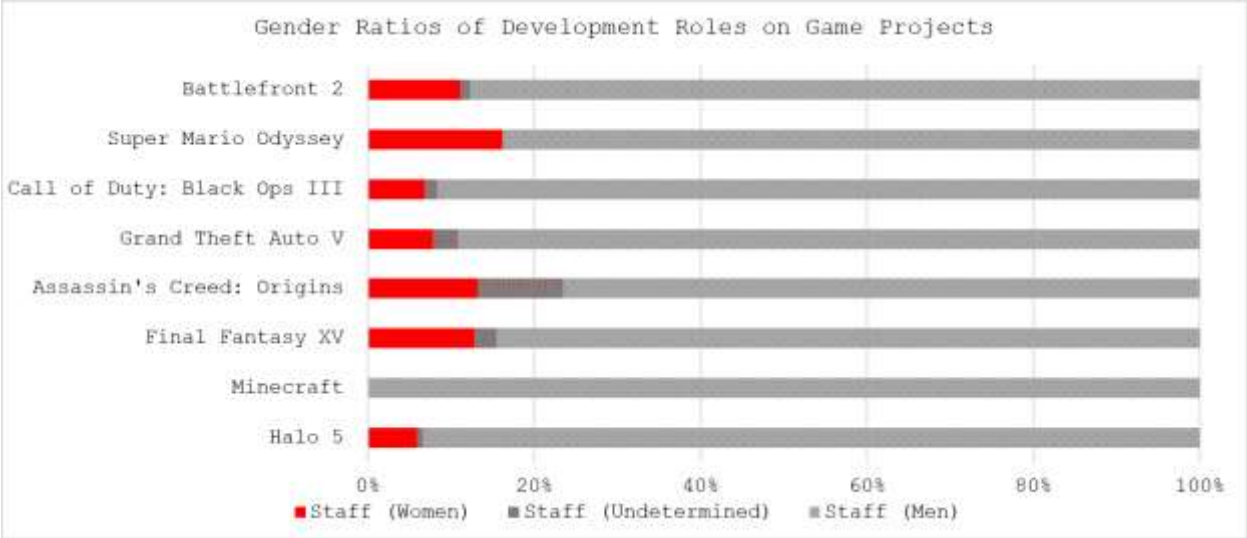

Figure 6-1. Gender ratios for development staff listed in video game credits.

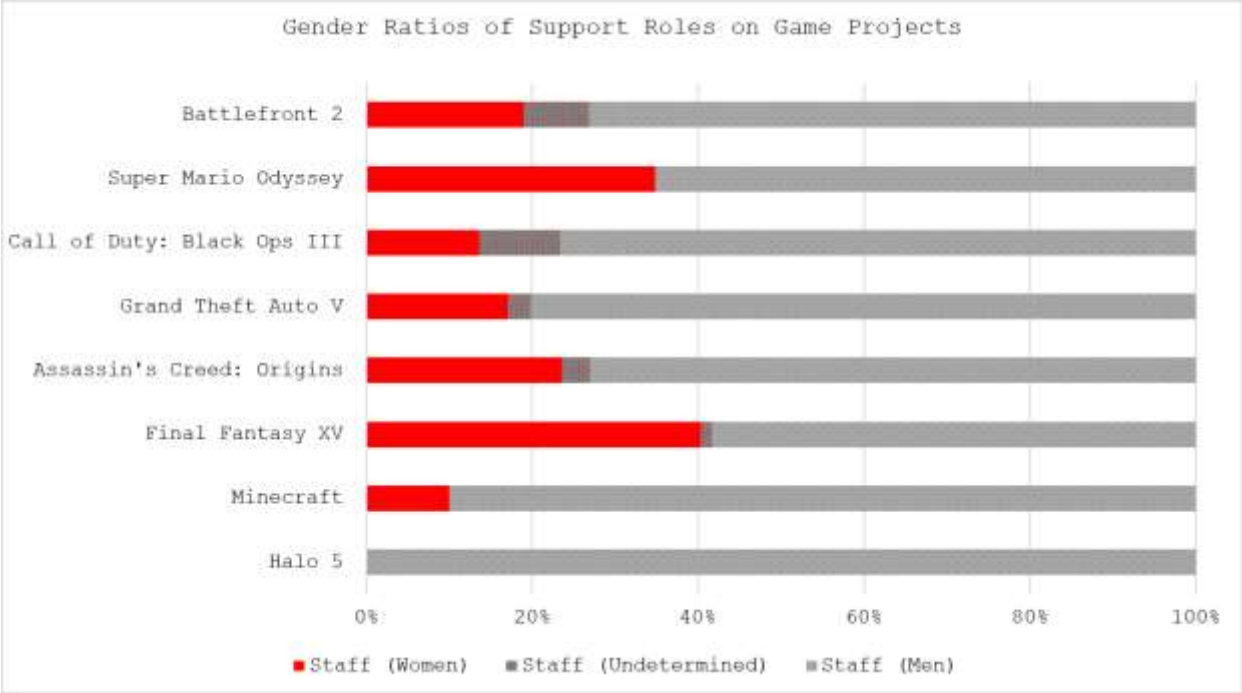

Figure 6-2. Gender ratios for support staff listed in video game credits.

Across every project, except for the special case of *Halo 5*, women were less represented on the development teams compared to support roles. For example, although *Super Mario Odyssey* had a high (35%) ratio of women to men in support roles, the ratio fell on the development team (16%). In *Halo 5*'s case, few support roles (10) were credited, so the lack of women in support roles (0) is more likely due to the way crediting was handled. We looked back at the earlier *Halo: Reach*, which did credit

many support roles (191) and confirmed a similar trend to other titles in the sample, with 12% (23 out of 191) of support roles being women, while only 2% of development roles (4 out of 201) were filled by women. In *Halo 5*'s case, less than 6% of development roles (16 out of 272) were filled by women, making it the game from the sample chosen for comparison with the lowest ratio of women to men.

To get a nuanced view of how gender ratios could affect pay disparity within the development team, we divided development roles into professional categories associated with salary survey data. Staff were categorized by whether they were in an audio professional role, a programming or engineering role, a project management role, an art or animation role, or a game design role. (Table 6-3)

Table 6-3. Gender ratios by professional role of the development staff listed in video game credits for games in the sample.

Video Game	Professional Role	Men	Women	Ratio of Women in Identified Sample	Gender Unidentified
Battlefront 2	Audio	19	2	10%	0 (0%)
	Programming	113	7	6%	1 (1%)
	Project Management	35	8	19%	0 (0%)
	Art & Animation	190	25	12%	5 (2%)
	Game Design	77	13	14%	0 (0%)
	Total	434	55	11%	6 (1%)
Super Mario Odyssey	Audio	9	1	10%	0 (0%)
	Programming	33	0	0%	0 (0%)
	Project Management	8	0	0%	0 (0%)
	Art & Animation	51	18	26%	0 (0%)
	Game Design	13	3	19%	0 (0%)
	Total	114	22	16%	0 (0%)
Call of Duty: Black Ops III	Audio	22	3	12%	0 (0%)
	Programming	93	2	2%	2 (2%)
	Project Management	37	0	0%	0 (0%)
	Art & Animation	207	21	9%	4 (2%)
	Game Design	84	7	8%	1 (1%)
	Total	443	33	7%	7 (1%)

Grand Theft Auto V	Audio	20	1	5%	0 (0%)
	Programming	131	6	4%	1 (1%)
	Project Management	29	1	3%	0 (0%)
	Art & Animation	243	33	12%	11 (4%)
	Game Design	99	5	5%	5 (5%)
	Total	522	46	8%	17 (3%)
Assassin's Creed: Origins	Audio	26	3	10%	0 (0%)
	Programming	255	16	6%	9 (3%)
	Project Management	23	9	28%	0 (0%)
	Art & Animation	259	76	23%	77 (19%)
	Game Design	155	20	11%	10 (5%)
	Total	718	124	15%	96 (10%)
Final Fantasy XV	Audio	7	4	36%	1 (8%)
	Programming	46	0	0%	3 (6%)
	Project Management	7	1	13%	1 (11%)
	Art & Animation	106	18	15%	0 (0%)
	Game Design	85	15	15%	3 (3%)
	Total	251	38	13%	8 (3%)
Halo 5	Audio	12	0	0%	0 (0%)
	Programming	48	2	4%	1 (2%)
	Project Management	1	0	0%	0 (0%)
	Art & Animation	161	13	7%	1 (1%)
	Game Design	32	1	3%	0 (0%)
	Total	254	16	6%	2 (1%)

Based on the 2014 *Gamasutra* salary survey (2014), we calculated the difference in salary from the average for each role represented. (Table 6-4) Audio professionals and programmers are well-compensated relative to the other roles, while game designers and artists or animators are less compensated.

Table 6-4. Relative pay differences by role based on the 2014 *Gamasutra* salary survey.

Professional Role	Average Salary	Difference from Overall Average
Audio Professionals	$95,682	+$11,796 (114%)
Programmers and Engineers	$93,251	+$9,365 (111%)
Producers	$82,286	-$1,600 (98%)
Artists and Animators	$74,349	-$9,537 (89%)

Game Designers	$73,864	-$10,022 (88%)
Mean Salary	$83,886	-

We grouped the roles into the same categories as the *Gamasutra* salary survey and determined the relative difference between the ratio of women in each role versus the overall gender ratio of the development team. (Figure 6-3) For example, the *Battlefront 2* development staff had an overall gender ratio of 11% women to men, but the actual percent of women in programming roles was only 6%, resulting in a -5% difference from the mean. This indicates that women are underrepresented in programming roles compared to other roles on the team.

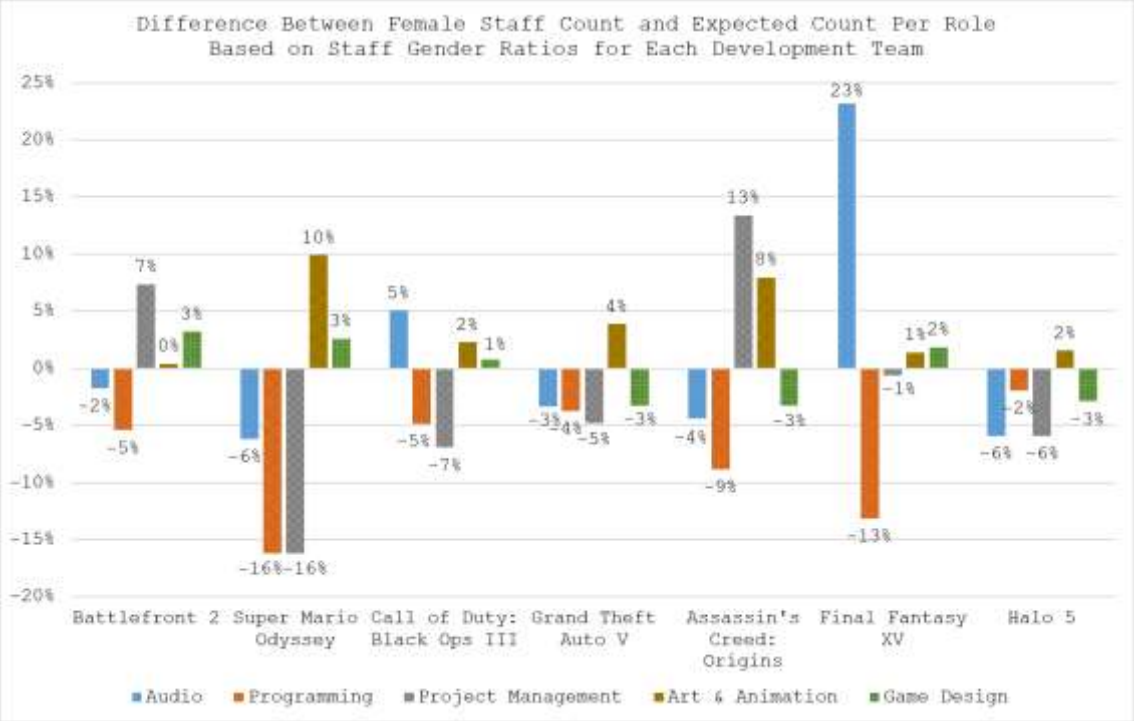

Figure 6-3. The difference in gender ratios by role from overall development staff ratios.

In general, women were overrepresented in art and animation roles, while they were underrepresented in programming and other engineering roles. Two large teams from the sample, *Super Mario Odyssey* and *Final Fantasy XV*, had no women in engineering positions, and the highest representations were on *Battlefront II* and *Assassin's Creed: Origins* with 6% of engineering roles filled by women. Sound designers, the most highly compensated based on the salary survey, were also underrepresented in most of the teams, with an exception for *Final Fantasy XV*, where women represented more than a third of roles. These two imbalances are likely to be

factors that affect the average salary of women compared to men in addition to potential equal pay for equal work issues.

6.3.2 Representation of women in creative leadership

When we categorized the roles in our sample by whether they were a leadership or a non-leadership role, the gap between men and women widened on several projects. (Figure 6-4) *Super Mario Odyssey*, for example, had a leadership gap of 16% below the development team's overall gender ratio. Even in support roles, there was a 13% gap for leadership below the overall support role ratio. One exception that had a higher ratio of women in leadership roles, *Battlefront 2,* had 2% more women in leadership roles than the overall development team gender ratio. *Assassin's Creed: Origins* was next, with a leadership ratio that reflected the composition of the development team.

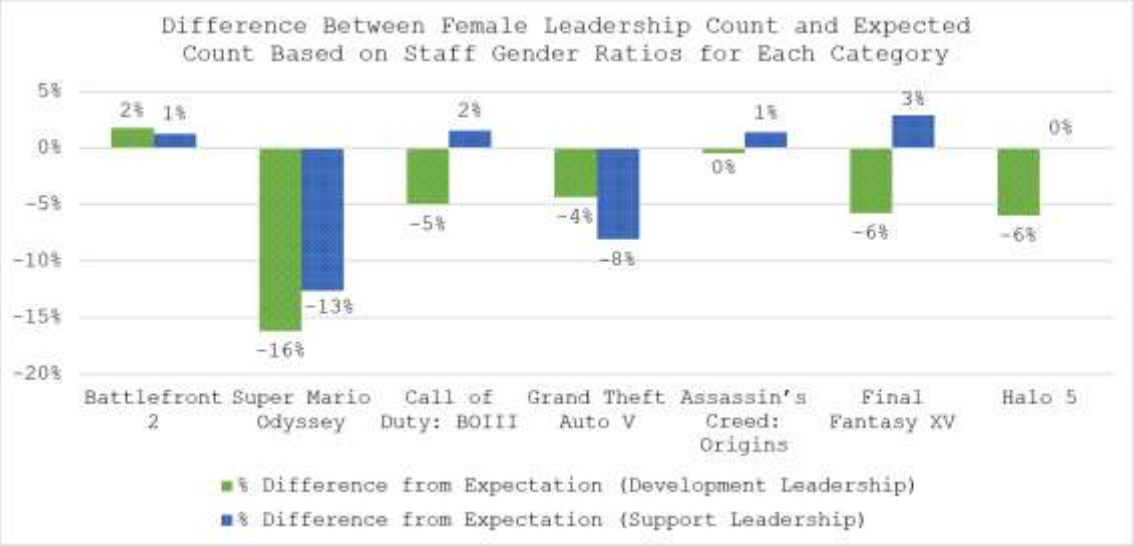

Figure 6-4. The difference in gender ratios for leadership roles from overall staff ratios.

To expand the leadership role analysis, we checked the gender of the director, executive producer, and producer roles for top-ten best-selling games for the period from 2001 to 2017. Of the 170 games in the sample, there were 73 unique directors, none of which were women; there were 60 unique executive producers, 2 (3%) of which were women; and there were 139 unique producers, 12 (9%) of which were women.

Another way to explore how women are missing from leadership roles in the industry is reflected in their presence as speakers at video game development conferences. Conferences tend to feature speakers who the industry judges "important".

However, until recently, only about 1 in 10 of speakers at the *Game Developer's Conference* (*GDC*) were women. (Markowitz and Gilat, 2015) To address the lack of inclusion, the conference is committed to addressing the issue (2019), and the ratio has changed over time. Markowitz and Gilat showed that the ratio of women had climbed to almost 20% in 2015. To verify the current ratio, we checked the gender of the 764 speakers listed for the 2019 conference and found that just under 25% (189 out of 764) of speakers were women – more reflective of the overall ratio of women in game development. However, without an awareness of the need to be inclusive and efforts to address the imbalance, the numbers fall. We checked the gender of the 387 speakers at the 2018 *Computer Entertainment Developers Conference* (*CEDEC*) and found that only 8% (31 out of 387) of speakers were women. Given the conference venue and focus on Japanese video game development, this could also be reflective of the larger leadership gap found with *Super Mario Odyssey* versus the other teams.

6.3.3 Representation of women in executive positions

A 2016 *McKinsey* survey of 233 companies and 2,200 employees found that, while many companies have attempted to address the gender gap in executive positions, few are achieving significant results. (Devillard et al., 2016) The same report notes that addressing gender and diversity issues is difficult without commitment from top management. However, women are often absent from the CEO and board positions who can provide this commitment. To discover how represented women were in corporate leadership for video game companies, we examined the gender composition for the boards of the top 25 publishers by revenue using annual reports and official sites. (Figure 6-5) In cases where a subsidiary of the parent organization was closer to the video game business and had an acting CEO, we chose the CEO of that subsidiary to represent the CEO position. In most cases, the CEO was also a member of the board. Of the 238 board members, 39 (16%) were women. Only in *Zynga*'s case were half the members of the board women, and only in a minority (5 of 25) of cases were there more than two women on the board. In the majority (14 of 25) of cases, there were either no women or only one woman on the board.

Figure 6-5. The gender representation for CEOs, insider board members, and other board members for the top 25 video game publishers by revenue.

To focus on board members who were close to the business and could provide commitment to change as well as drive game development goals, we further divided the data between board members who could be considered "insiders" – they had some role within the company – and the other, remaining board members, including external directors or auditors. In only one case, *DeNA*, was a woman either a CEO or an "insider" who could be seen as having an executive role in the daily business. The rest of the women holding board member positions held external roles. This is an important distinction to consider, because internal members are more likely to be the ones making game development decisions or influencing development hiring practices.

6.4 Visualizing Gender Distribution in Credits

Another way to determine the relative "importance" of staff and their influence on a project is by the ordering of their name listing in the video game credits. Like movies, a decision is made when determining the order of credits to put certain people

near the top, either because of the relative "value" of their contribution or their brand value. Although important staff are often saved for the end of the credits list, they usually consist of executive producers or directors, roles we have already determined to be dominated by men.

When we examined the credits from the sample, only one game, the original *Assassin's Creed*, had a woman leading the staff list. In every other case, a man led the list. We then determined the average staff list position for each gender and charted the distance from the median (50%). (Figure 6-6) Only *Final Fantasy XV* had what was close to "equal" billing for men and women; the average position for women was 176, 1% higher than the median out of a total of 360 names. *Super Mario Odyssey* had the largest gap, with the average position for women being 133 (15% lower than the median) out of a total of 205 names.

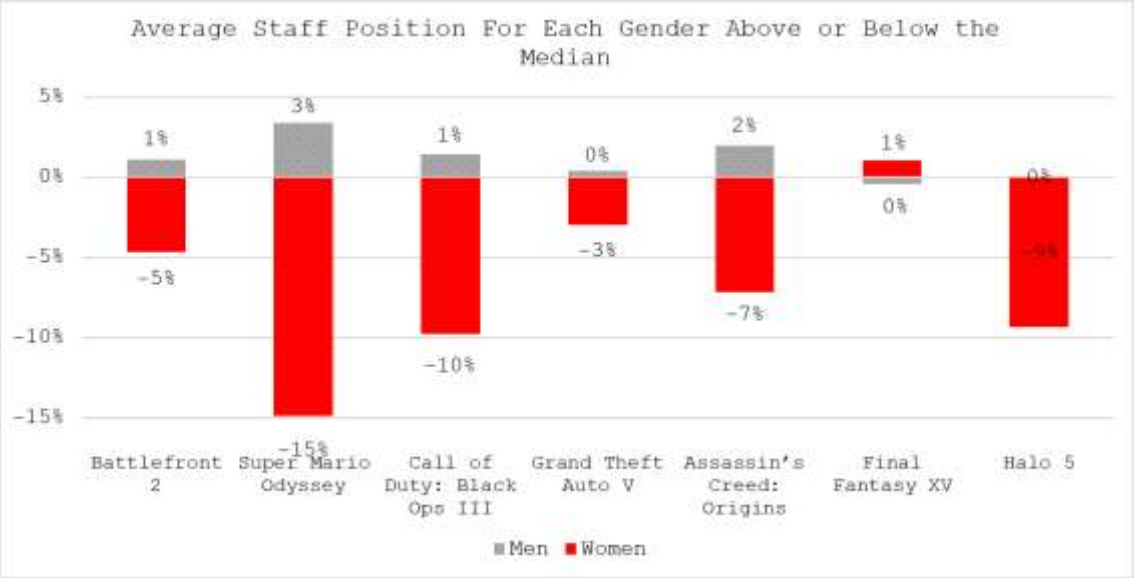

Figure 6-6. The average distance from the median for staff list placement by gender.

To discover trends basic statistical analysis could miss in staff list gender representation, we employed a visualization method that allows easy comparison of the composition between different teams of different sizes, while preserving the sense of ordering from top to bottom. (Figure 6-7) After we performed a bicubic resampling to resize all of the teams to the same size, using the smallest team as a base, it became clear visually that most staff lists in the sample are front-loaded with men. *Super Mario Odyssey* is the clearest example of the phenomenon. The results support our earlier conclusion that there is a gap between the gender composition of the overall team and

that of leadership, or “important” roles.

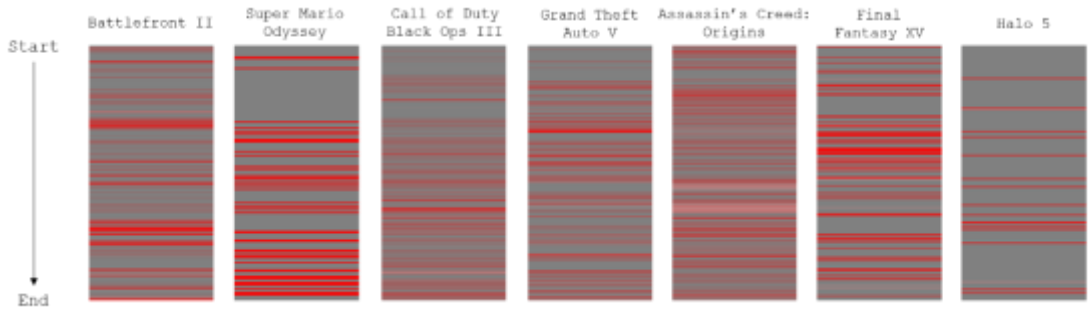

Figure 6-7. Color coded staff lists with the darkest color (red in color, dark gray in grayscale) for women, gray for men, and grayish pink (light gray in grayscale) for undetermined genders.

To make crediting trends easier to spot, we broke the visualizations into quartiles. (Figure 6-8)

Figure 6-8. Color coded staff lists with the darkest color (red in color, dark gray in grayscale) for women, gray for men, and grayish pink (light gray in grayscale) for undetermined genders broken into quartiles.

With the staff list broken into quartiles, it is clearer that the same trend is present in *Call of Duty: Black Ops III* and *Grand Theft Auto V* with a significant gray area indicating overrepresentation of men near the top of the list. *Halo 5* had few women overall, but the few that are present are mostly concentrated in the third quartile, where the art roles are concentrated. *Final Fantasy XV* appears to share the trend, but a closer examination of the credits reveals an unusual ordering by work units. As a result, the second quartile is largely comprised of support staff, while the first, third and fourth quartiles are composed of the development team. Thus, although the average listing we found through simple statistical analysis is higher for women than

men, this is mostly due to the unusual ordering of the support staff. Visually, *Assassin's Creed: Origins* is the closest to having a uniform spread of women and men throughout the credits. The women comprising the staff list in *Battlefront II* seem to be concentrated in several "clusters", which indicate that there are likely certain roles that are over and under-represented. A closer examination of the staff list revealed that many of the red (dark gray in grayscale) clusters correspond to support staff for the various studios and the publisher involved in making the game. In general, the results of the visualization technique support the individual conclusions discovered through statistical analysis, indicating it could be a useful method for spotting gender ratio trends in entertainment products such as games or movies and for spotting issues that statistical analysis could miss.

6.5 Consequences of the Gender Gap Results

The results from our research indicate gender gaps for all of the development teams in the sample and within the executive management of the top 25 video game publishers. When the gender ratios for teams developing the latest releases of best-sellers are compared to earlier games in the series, the overall gender gap has narrowed, but remains wide. For example, the gender ratio for *Nintendo*'s *Super Mario Bros.* franchise has changed from an all-male staff to above a 1:5 ratio of women to men; however, this includes support roles. When the focus is on the development team, the ratio across the sample is at best less than 1:6. In *Halo 5*'s case, the ratio of women to men on the development team is 1:17.

With so few women on a development team, there is little to prevent the work environment from being toxic, like the one reported by D'Anastasio (2018) at *Riot Games*, and make women want to leave. Developers and publishers who wish to better represent their players need to take steps to narrow this gap. A *National Women's Law Center* fact sheet suggests that making wages transparent could be one of the most important steps to dealing with gender-based pay inequalities. While the wage gap for all full-time workers was 20%, the wage gap between women and men was reduced to 13% for federal workers, whose pay ranges are made publicly available. (National Women's Law Center, 2018) Although the overall gender gap is important, other critical gaps exist and deserve particular attention.

One example of an important gap is the representation of women in higher-paying professional roles. Women are underrepresented in engineering roles for every game in the sample. This is the case even for the most recent iterations of each franchise, ranging from 4% below *Grand Theft Auto V*'s overall development team

gender ratio to 16% below *Super Mario Odyssey's* overall development team gender ratio. Lower paying art and animation roles are over-represented, up to 10% higher than the development team's overall gender ratio with *Super Mario Odyssey*. Also, except for *Battlefront 2* (2% more women in leadership than the overall development team gender ratio) and *Assassin's Creed: Origins* (a gender ratio for leadership that reflects the composition of the development team), women were underrepresented in leadership roles compared to their presence in the overall development team, with the largest gap being 16% below the development team gender ratio for *Super Mario Odyssey*. Given the salary statistics, these gaps are likely to result in further pay imbalances between women and men beyond "equal pay for equal work" imbalances. The lack of women represented in engineering roles is not unique to the video game industry, but these roles are highly compensated compared to others on the same team, so efforts need to be made to improve representation to address the wage gap.

In addition to the wage issue, another issue with the drop in representation is related to research by Kanter (1977) into how "skewed groups" containing an imbalance of "dominant" and "token" members can lead to issues for the minority group, such as performance pressures, exaggerated differences, and being entrapped in roles. Given the low representation of women in general on development teams, many of these issues are likely present at the team level, but they could be stronger on a micro-scale, such as within an engineering team, and the "fear of visibility" issues reported by Kanter could tie into the other imbalance: leadership representation.

No director from the 123 games in the top-ten best-selling games having an identifiable director in the credits was a woman, and only two executive producers from the 129 games in the top-ten best-selling games having an identifiable executive producer were women. Moving down a rank, only 15 of the 139 games in the top-ten best-selling games having an identifiable producer had women in the role – one of which, the original *Assassin's Creed*, was included in this sample.

On the business side, executive positions and boards of directors in top video game publishers are, like other industries, missing women. When present, they are external board members, such as external directors or auditors, who are not involved in daily operation. The only exception in the 25 companies examined was the founder and CEO of the 22nd largest publisher by revenue, *DeNA*. When the lack of women in executive leadership roles is considered together with the lack of women in creative leadership roles, there are few high-profile examples of women in video game development to counter the perception that the video game industry has a male-centric "bro culture" and few women in positions with significant power to address gender

imbalances or toxic environments. If employment in video game organizations is an unattractive option to women, it will be difficult to address the gender imbalances. With few women having creative voice, game design is left to men, who may not know how to create games that appeal to women. (Dickey, 2006) Given that, as of 2019, 46% of gamers are female (Entertainment Software Association, 2019), yet most resources go into developing games that appeal to men (Yee, 2017), a critical market is being left unserved that could be better served if talent management and human resource policies to address the gaps at all levels are implemented.

6.6 Quantifying the Gender Gap in Video Game Development

Through the results of our research, we analyzed 14,265 staff in 27 top-selling console games from major publishers and found that, not only is the gender disparity reported in developer surveys present, the concentration of women is in comparatively lower paying roles and outside of leadership. Although the gender gap in game development has improved over time, it is still far from representing the female gamer population, which has grown from 38% in 2006 to 46% in 2019 within the U.S. as an example (Gough, 2019), and the wage gap is likely to be even more difficult to close given the disparities present in high-paying roles and leadership.

Without improving the representation of women in the industry and in leadership roles, the problems with representation of women in video games posed by Williams et al. (2009) as well as issues like the pay gap reported for *Rockstar* in the UK and "bro cultures" like the one reported in *Riot Games* will likely continue. Although some companies are making their gender statistics more transparent, whether through corporate social responsibility efforts or government compliance, basic figures are not enough to expose how far video game companies are from reaching gender equality. In particular, some roles are rewarded, whether by pay, by creative voice, or by recognition, more than others. Developers and publishers need to recognize the need to track and publicize a detailed breakdown of what positions women are reaching and to take steps to fix each of the shortfalls if they want to address the issue. They must address these gaps if they wish to have a human resource base that can better serve the growing female game consumer market.

Breakdown and visualization methods, such as the ones used in this research, could help video game companies identify more specific areas that are underrepresented and help focus efforts to improve the resulting wage gap. As these methods rely on publicly available data, they should also enable those outside the companies to better discover and expose potential workplace issues, such as pay gaps or discrimination, that

need to be fixed before game development can better represent its players.

6.7 Utilizing KDD with External Data to Verify Decisions Regarding the Representation of Women in the Video Game Industry

The research presented in this chapter employed KDD techniques to quantify the extent of the gender gap, with a focus on roles with power or creative voice, in 27 teams within seven large video game organizations to answer the question:

- What role do women play in making creative decisions within video game development organizations and how does this compare to video game consumer demographics?

Given the limited number of creative voices that can drive a video game project, organizations must decide who will fill those roles and drive product designs that will satisfy consumer needs. The benefits of the knowledge gained through employing a KDD technique such as the one presented to decision-makers deciding who to hire or promote within their organizations or what HR management policies need to be implemented to better align the composition of their organizational members with creative influence over the products they design to the composition of the markets they wish to serve include the ability to set active gender representation goals at a more granular level throughout their organization. Understanding how women are represented in specific roles within the wider industry and competitors also presents an opportunity to actively correct tacit assumptions regarding who should fill which roles and how best to ensure the appropriate HR and talent management policies are in place to prevent discrimination or bias in human resource selection. (Figure 6-9)

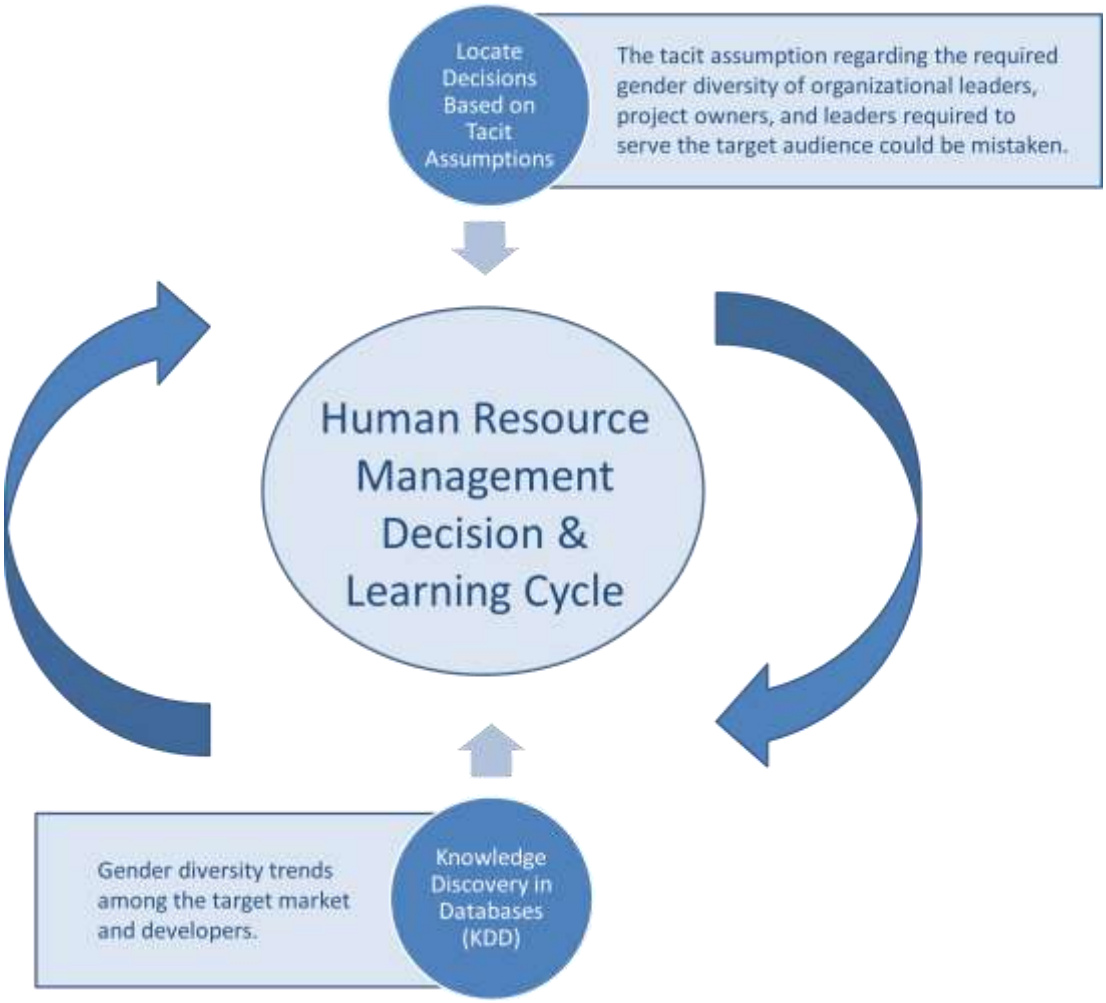

Figure 6-9. Incorporating industry-wide data to validate or position assumptions regarding gender diversity and representation in video game organizations.

7. An Analysis of Content Scope Decision Results in Video Game Projects

In Chapter 7, I analyze content scope decisions in video game development projects from 2005 to 2017. The research is the first part of the answer to the question:

- How do the product scope decisions made in video game project management reflect what provides value to consumers?

I explore the project management decisions made using data on 31,964 games from the largest retailer of PC video games, *Steam*. The results indicate that publishers are over-estimating the amount of content scope that their customers require.

Although directors and producers in charge of video game development projects rely on tacit knowledge from the experience they have accrued over their careers to decide the content their games should provide to players, their tacit knowledge might fail to reflect "how much game" players want.

The research presented in Chapter 7 shows how the mining of video game "achievement" data, representing the "finishing" of primary single-player content, can be used to find what percentage of players are completing games as well as the correlations of other factors to those completion rates. This research discovers that, on average, only a minority of players finish the games they begin. Understanding player content consumption patterns allows directors and producers to make better decisions regarding the product content scope and "how much game" they need to create, which could lead to a better use of resources in other areas such as quality.

7.1 Deciding Content Scope for Video Game Projects

One critical decision for any video game project is: How much game is enough? The amount of content developed affects the scope of the project, which determines resource and budget requirements. In addition, as the scope of any software project grows, the use of resources, particularly staff, becomes less efficient so that costs do not scale linearly with scope increases. (Boehm, 1983, Brooks, 1975, Jiang, 2007, Scott and Simmons, 1975)

With so much money at stake, publishers and studios in the video game industry need methods for deciding an appropriate project scope, not only to combat high budgets, but to make development more efficient with limited resources.

For typical software projects, value is easier to define as it can be determined by querying or analyzing more utilitarian customer needs, but in a video game project, customer and consumer needs are unclear. In most cases the consumer does not know what kind of game they want until they are playing it, and thus their needs must be predicted by a game project's director or producer, who provides a subjective opinion on what features or content will add value for the customer and subsequently increase sales and drive profits for the business that employs them. However, these product owner opinions may not reflect the realities of what users want. User testing may help to mitigate some of the risk, but user testing often occurs later in the project's development cycle, after many of the resources have already been spent.

Games are built for entertainment, not utility, so some subjective judgment regarding the value proposition the developers will make to consumers is unavoidable. Project scope, or "how much game to make," is one component of this value proposition, but it is an important one. Many game project managers as well as marketers assume that "more is better," but creating more game content requires more resources, and, after a certain point, additional content results in diminishing returns as the number of people who interact with the content falls. (Bauckhage et al., 2012, Sifa et al., 2014) In the publishing industry there are ideal ranges of content, in terms of word count, for different books in different genres, such as between 70,000 and 109,999 for English adult commercial and literary fiction, beyond which the additional content is not typically seen as offsetting the costs of printing. (Sambuchino, 2016) The same is likely true for video game content.

Although there are many possible definitions of value, if a player does not experience the content, then its presence likely provides no value to them. Finding a balance between enough game content to satisfy consumers without going too far and wasting resources is a difficult decision, but an important one for making sure a game business sees a return on its investment. It is also important to get scope "correct" early, because later cuts in scope could result in wasted resources or an incoherent game experience and hurt the value of the final product.

When the findings regarding non-linear costs of increasing software development project scope (Boehm, 1983, Brooks, 1975, Jiang, 2007, Scott and Simmons, 1975) are combined with the findings that there is a noticeable falloff in the players who continue to consume game content as time spent playing increases (Bauckhage et al.,

2012, Sifa et al., 2014), the potential for resource waste in game development projects becomes apparent.

Information regarding content usage patterns – specifically, how many players experience, or complete, all of the content provided – is critical for determining the ideal balance between the amount of content needed to provide satisfactory value to players and the budgetary resources required to produce that content. While research exists that analyzes trends with player engagement or content utilization for a limited number of video games, to the best of our knowledge, there have so far been no attempts to bring to light underlying game completion trends using a large source of data. This research examines video game achievements that signify the completion of single-player, main-path content in games sold through *Valve Corporation*'s *Steam* service. We use the ratio of players obtaining these achievements to determine how many players on average make it through the single-player content of the games they play. We also test correlations with other factors including ratings, player population, play time, price, genre, and release date to identify trends in those factors related to "completion rates" and identify outliers. Also, to show how the results of this research can be applied to a game project in development, we provide an example of how completion rates and playtimes of existing titles can inform the decision-making process on new projects. The results of this research help identify opportunities to reduce the content scope of video game projects.

7.2 Analyzing Content Scope Decisions Using Knowledge Discovery in Publicly Available Databases

For this research, we gathered data from publicly available sources on video game products released through *Valve Corporation*'s *Steam* service. In particular, we focus on video game achievements, which we examine for the presence of an achievement signifying that the single-player, main-path content has been completed by the player. From the ratio of players obtaining this achievement, we obtain content "completion rates" for each of the games in the research sample.

Then we perform statistical analysis on correlations between these completion rates and other factors, such as user and critic ratings, number of players, median play time, price, genre, and release date. Once simple pairwise correlation analysis is complete, we analyze the effect of the factors together through linear regression. Finally, we identify outliers that could provide examples of games with both high completion rates and high ratings.

7.2.1 Focus of content scope analysis

This research focuses on the single-player content developers require players to complete to reach an "ending" to the game, which excludes optional content, such as downloadable or side-mission style content. This also excludes multiplayer content, as the value proposition of multiplayer content, which is usually designed for repeated play, is going to differ from that of single-player content, which is often designed for one or a limited number of playthroughs.

Although there has been prior research into measuring player engagement (Bauckhage et al., 2012, Canossa et al., 2011, Nozhnin, 2012, Phillips, 2010, Sifa et al., 2014, Weber et al., 2011a, Weber et al., 2011b, Zimmermann et al., 2012), this research focuses specifically on "completion" of games as a method for measuring how many players are benefitting from all of the game content created.

To keep the data stable for analysis, data was collected only for games released on *Valve Corporation*'s *Steam* service up through the end of 2016. This research also focuses only on games that are sold through the service, which excludes free-to-play (F2P) games, with the assumption being that they operate on a different consumption and business model; F2P games are typically built with minimum launches and then content scaled according to consumption patterns. Also, only in rare cases do they rely on one-time use content, because they would be unable to generate revenue if their players completed the game.

7.2.2 Publicly available database sources used in the analysis

We pulled data from publicly available sources on the web, including *Valve Corporation*'s *Steam Store*, and third-party data-aggregating sites *Steam Spy*, *SteamDB*, and *HowLongToBeat*. The *Steam Store* pages also include aggregated critic ratings from the third-party site, *Metacritic.com*. The data obtained from these sources was combined into one entry for each application on *Steam*, uniquely identified by its AppID.

7.2.2.1 Steam Store

The primary source of data used in this research to determine completion rates is achievement data for video games released for the PC market on *Valve Corporation*'s

Steam platform. For every achievement, the *Steam* service provides publicly accessible data on achievement rarities in the form of what percentage of players have unlocked each achievement. If an achievement denotes the completion of a game's single player content, then its rarity will denote the rate of players completing that content.

The *Steam* platform was chosen because it provides publicly accessible data; however, it should be noted that results may differ from those of *Sony* or *Microsoft*'s platforms, for example, due to such factors as difference in user bases, differences in hardware platforms, difference in sales methods (all digital versus a combination of physical and digital sales), and differences in pricing schemes (reliance on retailers to sell physical copies likely limits some platformers in their ability to freely price or discount software, for example).

A list of applications on *Steam* was obtained through its API from the link: http://api.steampowered.com/ISteamApps/GetAppList/v0001/. Each entry in this list has an "appid" application ID field with a unique identifying number as well as a "name" field with a descriptive title. These application ID fields can then be used as an identifying key to access further information on the application within *Steam*'s *Store*, or on external sites. For example, the official "Steam Store" page for application ID 49810, *Dragon Rage*, can be retrieved through a link of the form: http://store.steampowered.com/app/498190. These store pages include information such as the game's name, user ratings and reviews, *Metacritic* aggregated critic ratings, price, achievement support, genre tags, publisher, and release date.

More detailed information is also contained within the web page's HTML markup. For example, in the *Steam Store* page, *Dragon Rage* had a "Mostly Positive" rating based on "94 reviews", but the HTML includes the information "76% of the 94 user reviews for this game are positive," as well as statistical data that shows the "ratingValue" is "7", the "bestRating" is a "10," and the "worstRating" is a "1."

Using the same application ID, additional data can be accessed through the "Steam Community" site. For example, achievement data can be retrieved for the game Dragon Rage by using a link of the form: http://steamcommunity.com/stats/498190/achievements. From these pages, information on achievement names, descriptions, and rarities can be found.

7.2.2.2 Steam Spy

Steam Spy is a website created by Sergey Galyonkin to analyze various trends for video games released on *Valve Corporation*'s *Steam* service. The same application ID

used for accessing games through *Valve*'s services can also be used on the *Steam Spy* site. Using the *Dragon Rage* example, information on the game can be accessed through the link: https://steamspy.com/app/498190.

In addition to the information included on the *Steam Store* page, there are detailed statistics covering: the number of people who own the game, the number of players, the number of people following the game on *Steam*, the number of *YouTube* uploads, the average and median time the game is played by players, the number of *Twitch* streamers streaming the game, player geographical distributions, and price movements. The *Steam Spy* statistics are based on the results of sampling *Steam* user profiles, which contain playtime statistics for each game in the player's collection. The number of players represents the number of people who own the game and have playtime registered, indicating they have "played" the game at least once.

For the purposes of this research, the number of players and median playtime were obtained from *Steam Spy* only for the games with achievement implementations. The number of players was favored over the number of owners given the nature of the research, which focuses on statistics obtained from players of the game. Median playtimes were favored over average playtimes because the research focus is on the overall population of players, and median playtimes would be less susceptible to extreme outliers, such as "hardcore" players investing far more time into the game than other players.

7.2.2.3 SteamDB

SteamDB, created by "xPaw" and "Marlamin," is a site that combines data gathered from the *Steam* API with *Steam Spy* data. Like the other two sites, the application ID can be used to locate the data for individual games. For the *Dragon Rage* example, the link would be of the form: https://steamdb.info/app/498190/. In addition to the information that can be found at those two sites, the *SteamDB* pages include current and historical pricing data in various currencies. For this research, the pricing data was checked only for games with achievements implemented.

7.2.2.4 HowLongToBeat

HowLongToBeat is a website containing user-submitted statistics related to how long it takes to complete single-player content for games on *Steam* and other platforms, divided into categories based on whether the time covers only the main-path

content or includes optional side-content. For the purposes of this research, we used the "Main Story" category average statistic that ignores optional side-content to provide another perspective on how play lengths could relate to ratings.

7.2.3 Data transformations

Python was used to convert the raw XML data obtained from the *Steam* API as well as the HTML data obtained from the *Steam Store*, *Steam Spy*, and *SteamDB* into a database-friendly format. *Python* was also used to perform some pre-processing of the data, which was stored in text, scanned using a grep tool, and reduced to the required data with pattern matching.

Application IDs and names were pulled from the *Steam* API; presence of achievements, presence of single player content, genre tags, release dates, user ratings, *Metacritic* ratings, developers, and publishers were pulled from the *Steam Store*; achievements and rarities were pulled from the *Steam Community* site; the number of game players as well as median play times were pulled from *Steam Spy*; and pricing information was pulled from *SteamDB*.

A random sample of entries with achievements was manually inspected for completion achievements. For example, the game *Psychonauts* (AppID: 3830) contains the achievement "I Thought That Was Unbeatable!" with 11.6% of players who started the game at the time it was inspected having obtained the achievement. In some cases, the achievement descriptions were enough to determine the appropriate game completion achievement, but often the entries needed to be checked against other sources to determine what, if any, achievement marked completing the single-player content. In the *Psychonauts* example, the description did not contain a clear sign that the achievement was equivalent to completing the game; however, a strategy guide for the game indicated that the final "level" of the game was the "Meat Circus" level, which meant the above achievement, with the description "Complete Meat Circus", was given for completing the final level of the game and thus appropriate for use as a completion rate. When necessary, the *Steam* community group was checked, followed by a wider internet search for walkthroughs or achievement guides. Games with smaller followings often did not have enough information to determine completion achievements. If there was no completion achievement, or the completion achievement was split depending on story choices or difficulty choices, the entry was marked as unknown. Also, if the completion achievement was unclear, or the data pattern indicated the achievement

implementation may be broken, the entry was marked as unknown. In all of these "unknown" cases, the data was pruned from achievement statistic calculations.

The processed text data was imported into *Excel* and stored in separate sheets, then aggregated into a single summary sheet through links. *Excel* was also used for basic calculations including means, medians, standard deviations, minimums, maximums, and some confidence intervals as well as for histogram and scatter plot graphing.

The summarized *Excel* data was exported to a comma-separated format for import into the open-source statistical package, *R* in order to perform more detailed statistical processing, such as correlation and regression analysis, and graphical visualization.

7.2.4 Data modeling

For this research, we performed basic statistical analysis on both completion rates and other factors before testing the correlation between those factors and completion rates. We then combined the individual factors to see what effects they had together in multivariate regression analysis, and finally checked for outliers to discover unique cases that could provide insight into games that have both high completion rates and high ratings.

7.2.4.1 Statistical analysis

Means (M) with 95% confidence intervals (95% CI), medians (Mdn) with interquartile ranges (IQR), minimums, and maximums were calculated for completion rates and other factors used later with completion rates in correlation testing. Distributions were also graphed to present a visual overview of the data.

In most cases, the data was not normally distributed and contained influential outliers, so interquartile ranges were calculated instead of standard deviations to more accurately depict data distribution trends.

7.2.4.2 Correlation testing

Correlations between several factors that could relate to completion rates were tested, including: user and critic ratings, number of players, median playtimes, price, genre, release date, and publisher.

Spearman's rho (r_s) and Kendall's tau (r_t) were reported instead of a Pearson's correlation coefficient because they do not make any assumptions about the frequency distribution of the variables. The value of rho ranges from -1 to 1, with -1 indicating the relationship between the ranks of the two elements being compared are completely opposite, while a value of 1 indicates that they are the same. A value of 0 would indicate no rank relationship. Correlations with null hypothesis p-values of less than .05 were considered statistically significant.

For testing correlations with categorical data, analysis of variance (ANOVA) with the F-test was performed to find the F-ratio. An F-ratio of 1 indicates the two variances being compared are roughly equal, while higher numbers indicate the variances are different. F-tests with F-ratio values higher than 1 and null hypothesis p-values of less than .05 were considered statistically significant in this research.

To test significant variation between ratings for games with different ranges of median playtimes, two-sample Kolmogorov-Smirnov tests were performed for each playtime category. The two-sample Kolmogorov-Smirnov test was also used to test significant variation in completion rates for games with different genres. The advantage of the Kolmogorov-Smirnov test is that it does not make any assumptions about the data distribution. Results with $p < .05$ were considered statistically different from the larger sample. With the Kolmogorov-Smirnov test, the D-statistic indicates whether two distributions are different; the larger the D value, or the absolute maximum distance between the cumulative distributions of the two samples, the more different the two sample distributions. In this paper, the D values are reported with the individual genre sample size on the left and total genre sample size on the right within parenthesis for reference.

7.2.4.3 Multivariate regression analysis

Ordinary least squares (OLS) regression analysis was performed on the factors found to have significant correlation to completion rates. The full model was analyzed first, followed by a more parsimonious, refined model based on the significance of the factors in the full model. Given the skewed nature of the data, the logarithms of independent variables were used. For the category of "genre", games can be tagged with multiple genres, so each genre was converted into a factor with a value of 0 (not of that genre) or 1 (of that genre).

We calculated both the R^2 and Adjusted R^2 to indicate the goodness of fit, where 1 indicates the predictions from the regression model perfectly fit the data and 0

indicates that none of the variability is explained by the model. We also calculated the F value, a ratio of the mean regression sum of squares to the mean error sum of squares, to find the significance of the regression model. Models with a p-value of less than .05 were considered statistically significant in this research.

7.2.4.4 Outlier testing

Outliers were sought within the sample that demonstrated high completion rates compared to the rest of the sample. The focus was on finding games that could provide examples of maintaining both high completion rates (several standard deviations above the mean, for example) and high ratings.

7.3 Completion Rates for Games on *Steam*

A total of 31,964 entries on *Steam* with unique application IDs were found. Of these entries, 6,462 had implemented achievements. Entries were selected randomly and manually checked for the presence of a single-player content completion achievement that could be obtained regardless of difficulty levels or gameplay choices. If present, and no pattern indicating an achievement implementation issue was present, the percentage of users obtaining this achievement was recorded. The mean and median were calculated as the samples were gathered, and testing was stopped when increasing the sample size no longer affected the result. In the end, 1,616 (25% of the sample with achievements, games only) were checked, providing 725 samples with completion achievements. The size of the final sample compared to the size of the other steps is summarized in Figure 7-1.

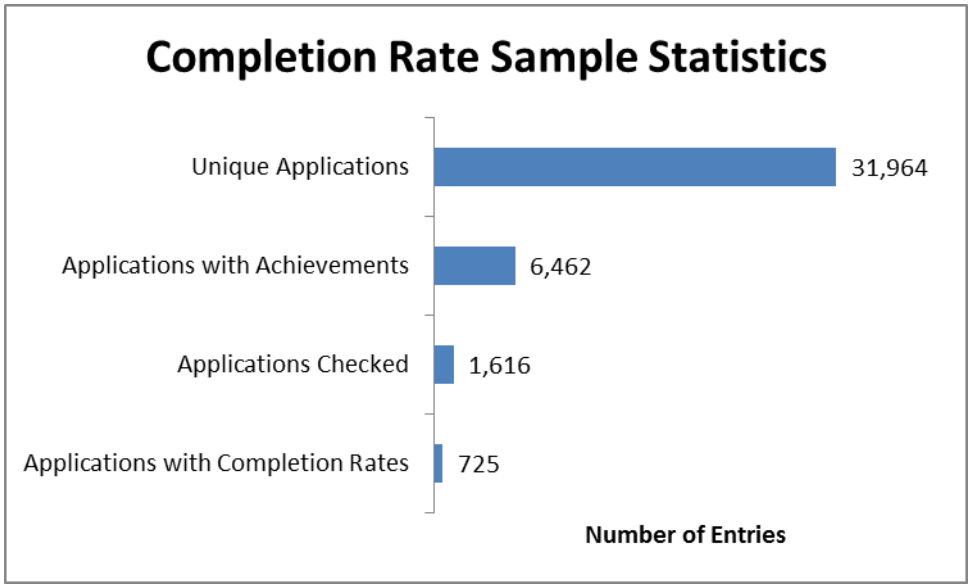

Figure 7-1. The sample sizes for the steps in this research.

With 725 samples, the mean "completion rate" was 14% (95% CI [13%, 15%]) and the median was 10% (IQR = 5 – 21%) with a minimum of 0.2% for the game *Poly Bridge* and a maximum of 56.1% for *The Walking Dead: Season Two*. The distribution of average completion rates from the sample is shown in Figure 7-2. For about half (51%) of the games measured on *Steam*, 10% or fewer of players finish the game. Only 2% of games had more than half of their players (>50%) seeing the game through to the end. The distribution is highly skewed towards low completion rates with a long tail towards higher completion rates.

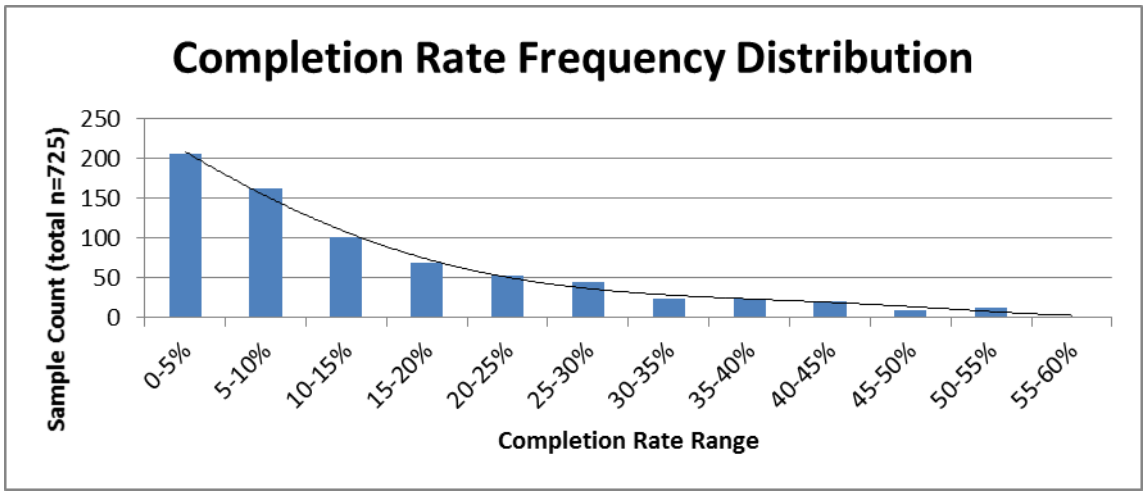

Figure 7-2. The frequency distribution for *Steam* game completion rates.

7.3.1 Summary of other factors

Before finding correlations between completion rates and other factors, summary statistics for the remaining factors were calculated. (Table 7-1)

Table 7-1. Summary statistics for the data factors checked on *Steam*, *Steam Spy*, and *SteamDB.*

Factor	N	M (95% CI)	Mdn (IQR)	Range
Completion Rate	725	14% (13 – 15%)	10% (5 – 21%)	0.2-56.1%
User Rating	17,990	75% (75 – 76%)	81% (63 – 94%)	0-100%
Metacritic Rating	2,531	72% (72 – 73%)	74% (66 – 80%)	20-96%
Steam Spy Players	5,473	155K (136 – 174K)	15K (4 – 73K)	616-29.8M
Steam Spy Median Playtime	5,473	3.8h (3.7 – 4.0h)	2.8h (1.4 – 4.1h)	0.03-82.5h
SteamDB Price	5,616	$10.27 ($10.04 - $10.49)	$9.99 ($4.99 - $14.99)	$0.49-$59.99

7.3.1.1 Ratings

User and *Metacritic* ratings in the sample are positively correlated ($r_s = .56$, $p < .001$, $r_\tau = .41$, $p < .001$) with each other, as could be expected given that they are both related to the perceived "quality" of the game they measure; however, there are differences in their distribution. User ratings are, on average, higher than *Metacritic* ratings, which aggregate scores from professional reviewers, but also use more of the 0 – 100% scale. (Figure 7-3) This makes intuitive sense as players are more likely to purchase games they are interested in, as opposed to professional reviewers who are more likely to be assigned games to review. Professional reviewers are also more likely to consider their scores from a critical perspective against other games in their experience, resulting in higher inter-critic correlation. (Boor, 1990, Boor, 1992, Johnson et al., 2014)

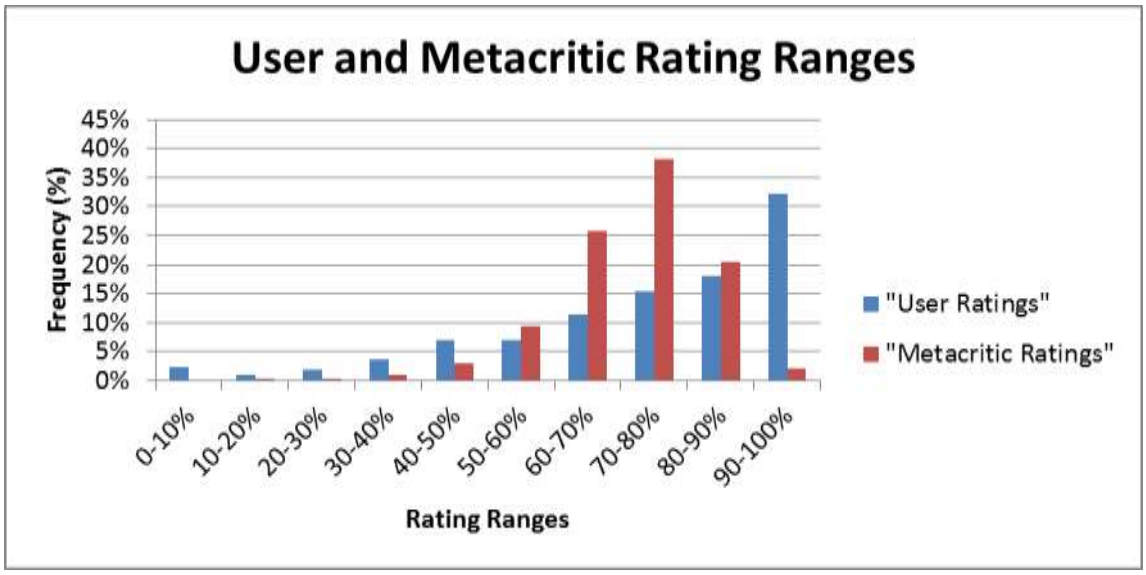

Figure 7-3. Relative frequency distribution of game rating ranges for user ratings and *Metacritic* ratings in the research sample data.

7.3.1.2 Popularity

With the number of players per game (Figure 7-4), the striking difference between the mean and the much lower median, as well as the wide interquartile range, demonstrates that there are a few powerful "hits" that skew the average.

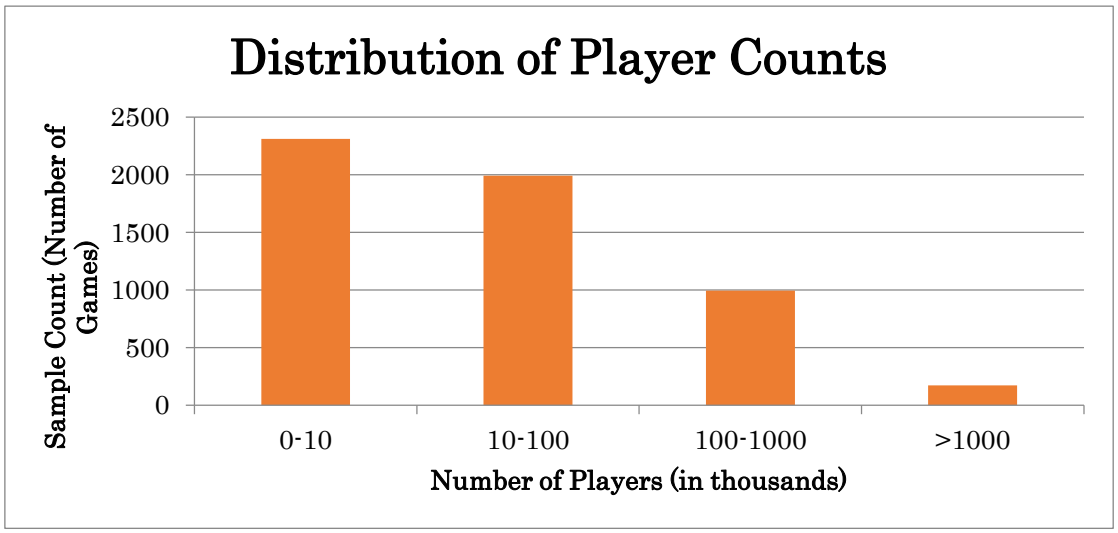

Figure 7-4. Distribution of *Steam Spy* game player counts in the research sample data.

7.3.1.3 Playtimes

With regards to playtime, *Steam Spy* provides both "average playing time" and "median playing time" statistics for each game. For the purposes of this research, we focused on the median play time because it would be less sensitive to outliers. The distribution of playing time ranges for games with achievements and *Steam Spy* data are shown in Figure 7-5. A minority of games (17%) had median playing times of over 5 hours and few (5%) over 10 hours. The game with the largest median playing time (82.5h) was the multiplayer game *Counter-Strike: Global Offensive*.

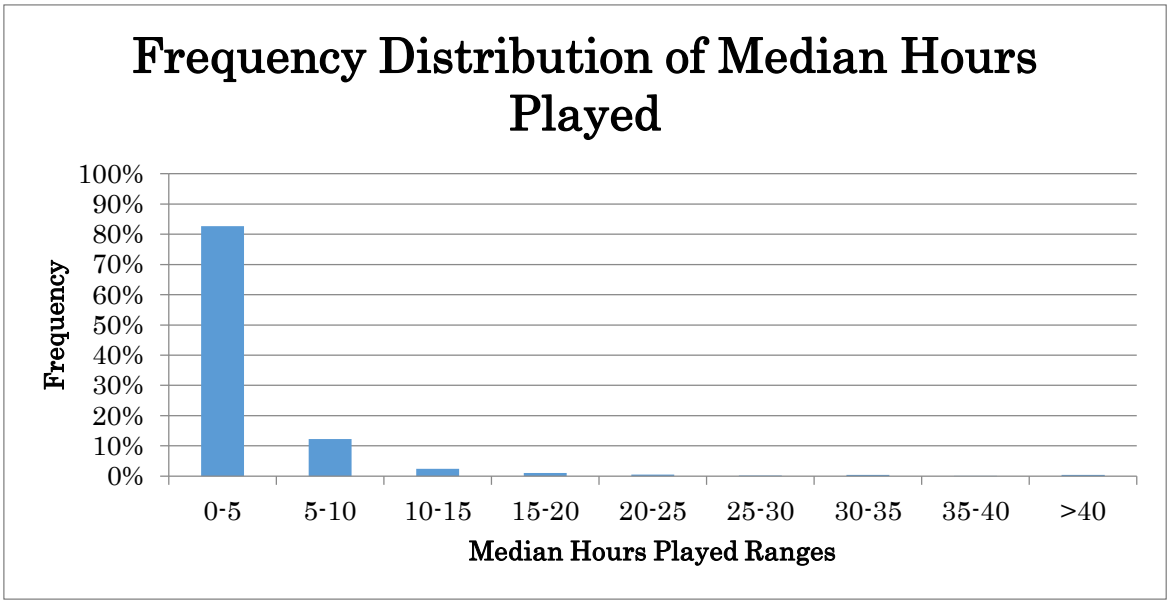

Figure 7-5. Relative frequency distribution of median hours, based on *Steam Spy*, spent in the research sample data.

7.3.1.4 Pricing

SteamDB data was used as the source for current pricing, which is the price of the game when it is not on sale; however, it does reflect price cuts compared to its original release price. As with many products, certain price points ($9.99 as opposed to $10.50, for example) are favored over others for psychological appeal, resulting in the presence of clusters of prices. Rather than plot the prices as continuous, they were split into logical categories ($0.49 – $2.99, $3 – $9.99, $10 – $19.99, and $20 – $59.99) for analysis. The majority (70%) of games were less than or equal to $9.99. (Figure 7-6)

Figure 7-6. Pricing distribution, divided by price range, of games sold through *Valve*'s *Steam* service through 2016 for the 5,616 games sampled.

7.3.1.5 Genre

Games on *Steam* can be tagged with one or more genres by the service, and these tags were used to determine how many of each genre existed on the *Steam Store* for the 22,511 entries with genres. (Figure 7-7) The most common tag is "Indie," representing independently developed games, with the second most common tag being "Action." Tags for genres outside of video games, such as "Accounting", "Animation & Modeling", "Audio Production", "Design & Illustration", "Education", "Photo Editing", "Software Training", "Utilities", "Video Production", and "Web Production" were excluded from the following statistics as there is no game or completion condition. These categories were also manually excluded from other calculations.

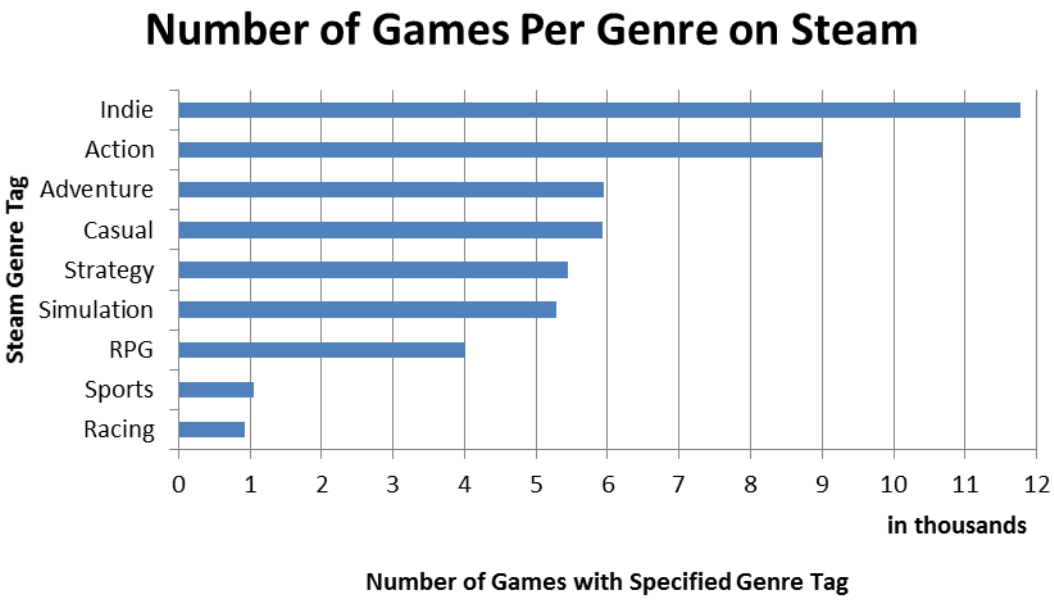

Figure 7-7. The number of games on the *Steam Store* for the 22,511 entries checked with each genre tag listed.

7.3.1.6 Release dates

Release dates were available for 22,498 entries on the *Steam Store* in the sample data set. The number of games being released on the *Steam* platform has risen steadily every year since 2007. More than a third (37%) of games released on the *Steam* service leading up through 2016 were released that last year. (Figure 7-8) This is close to the number (38%) reported through earlier findings by Wawro (2016) using *Steam Spy* data.

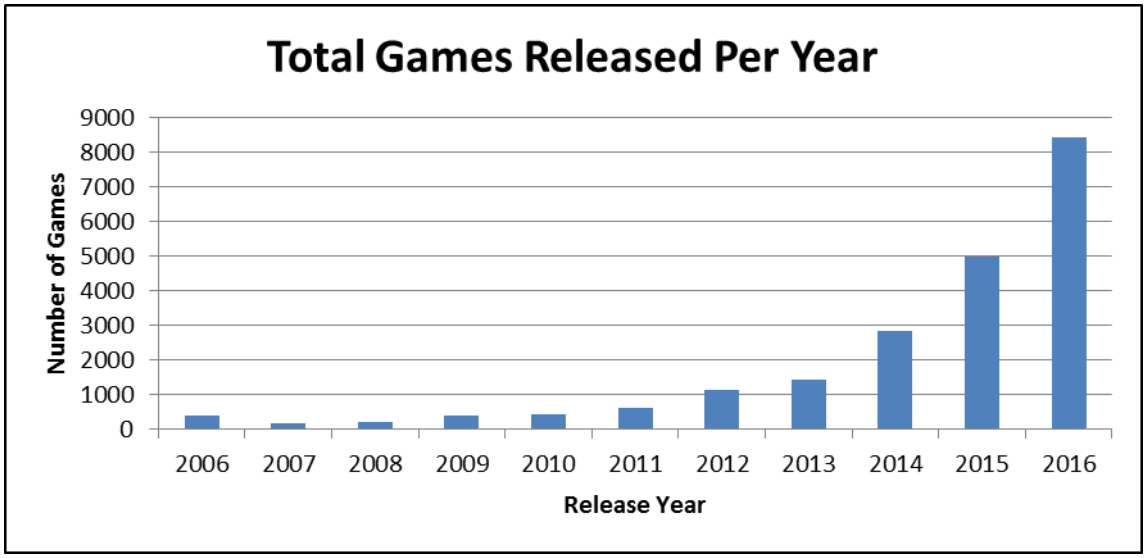

Figure 7-8. The number of games released on *Steam* per year through 2016 based on the 22,498 entries in the sample data with release dates.

7.3.2 Correlations between completion rates and other factors

Correlations between completion rates and the other factors listed in Subsection 7.3.1 were calculated. A summary of the findings is presented in Table 7-2; however, we will present a more detailed version of each of the findings.

Table 7-2. Summary statistics for correlations between completion rates and other factors.

Factor	Spearman's Rho	p value	Kendall's Tau	P value
User Ratings	.17	.022*	.10	.023*
Metacritic Ratings	.23	<.001***	.16	<.001***
Steam Spy Players	.16	<.001***	.11	<.001***
Steam Spy Median Playtime	.28	<.001***	.19	<.001***
Price	.21	<.001***	.15	<.001***
Release Year	-.08	.039*	-.06	.036*

* = p <.05, ** = p <.01, *** = p <.001

7.3.2.1 Completion rates and ratings

The first correlation analysis was performed between completion rates and two ratings: *Steam* user ratings and *Metacritic* ratings. When tested against completion rates, the trend was for completion rates to rise with both higher user ratings (Figure 7-9) and *Metacritic* ratings (Figure 7-10). Although completion rates and user ratings (r_s = .17, p = .022, r_τ = .10, p = .023) were correlated, there was a stronger correlation between completion rates and *Metacritic* ratings (r_s = .23, p < .001, r_τ = .16, p < .001).

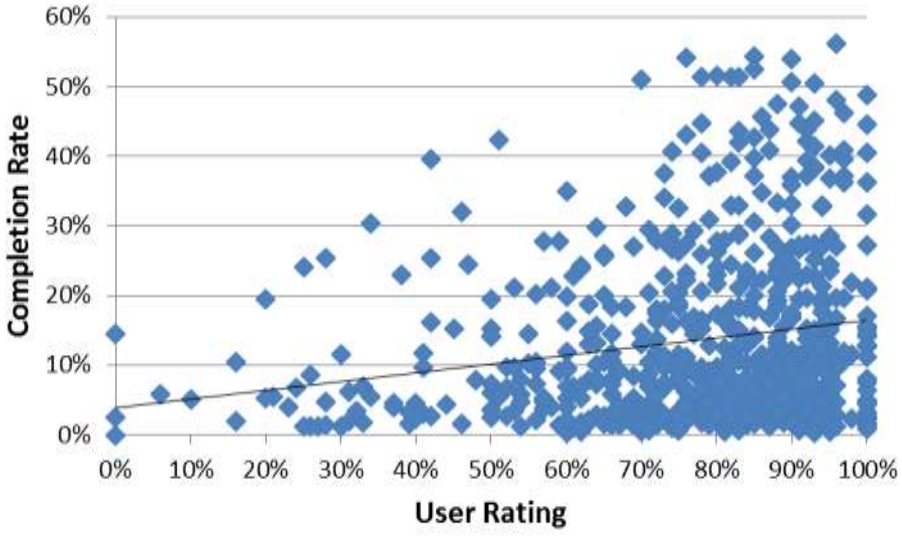

Figure 7-9. The relationship between *Steam* user ratings to completion rates in games on the *Steam Store* having achievements signifying single-player game "completion."

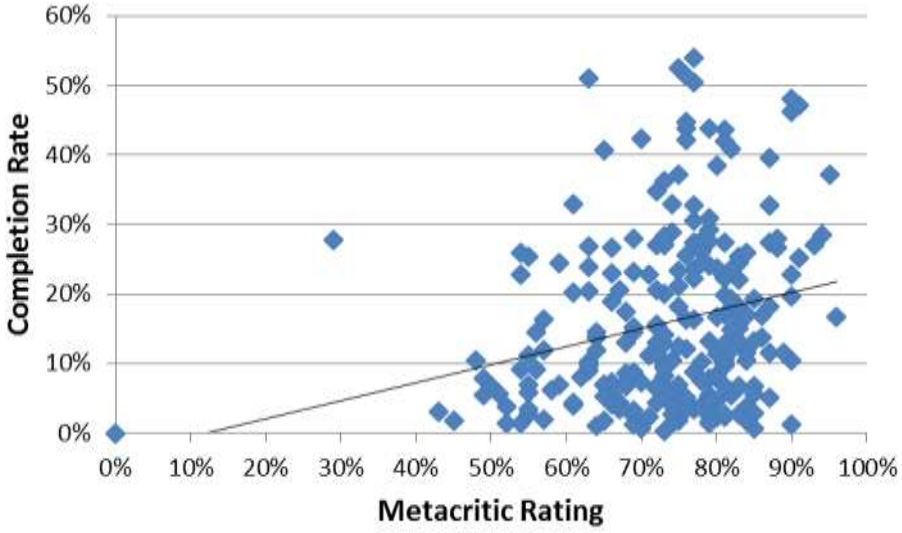

Figure 7-10. The relationship between *Metacritic* ratings to completion rates in games on the *Steam Store* having achievements signifying single-player game "completion."

However, it becomes more informative to break games down into categories. For this research, the categories used were: Poorly Rated (0 – 70%), Moderately Rated (70 – 85%), and Highly Rated (85 – 100%), with any games rated on the border being included in the higher category. When done so, ratings depict a strong picture of how players are more likely to have completed highly rated games. The primary distinction exists between Poorly Rated and non-Poorly Rated games (Figure 7-11); however, with *Metacritic*, and the tendency of critics to rate in a narrow range, the Moderate category takes on more meaning (Figure 7-12).

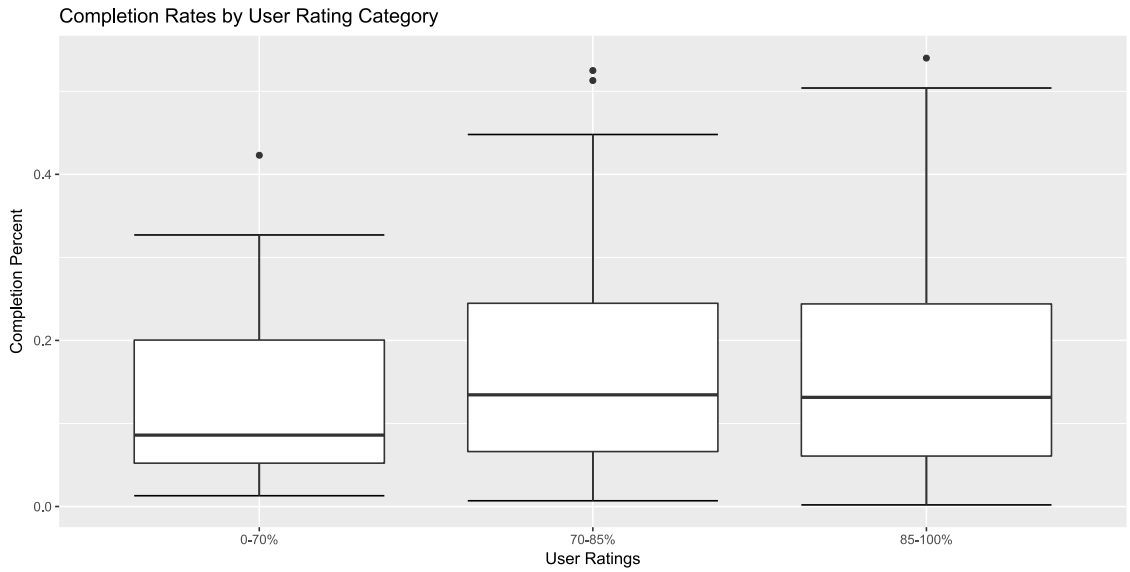

Figure 7-11. The relationship between *Steam* user ratings and completion rates when user ratings are divided into three categories representing poorly rated (0 – 70%), moderately rated (70 – 85%), and highly rated (85 – 100%) for games on the *Steam Store* having achievements signifying single-player game "completion." Dots indicate outliers within each category.

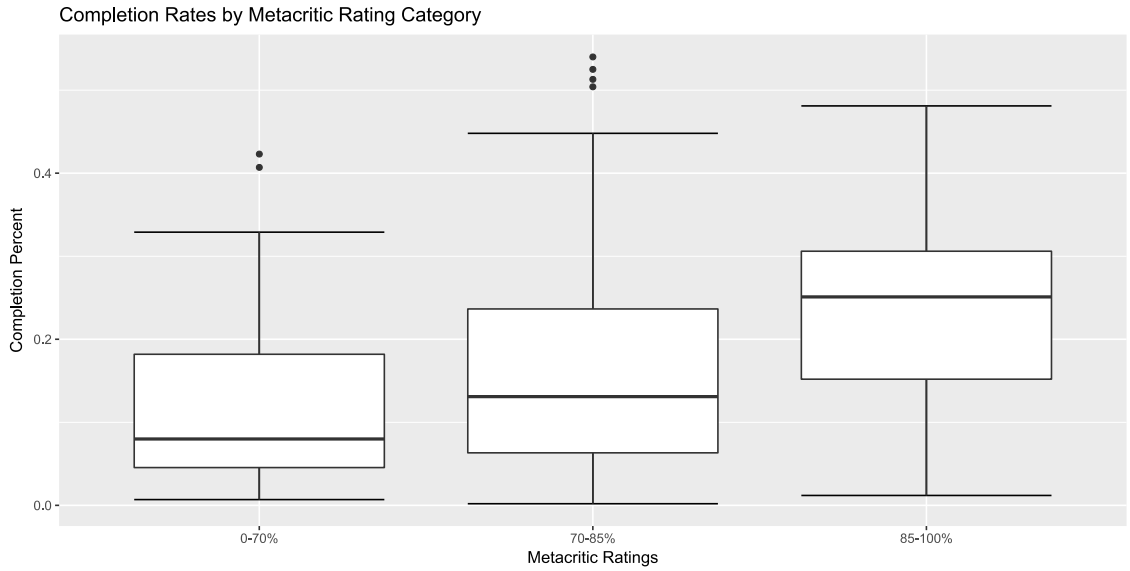

Figure 7-12. The relationship between *Metacritic* ratings and completion rates when user ratings are divided into three categories representing poorly rated (0 – 70%), moderately rated (70 – 85%), and highly rated (85 – 100%) for games on the *Steam Store* having achievements signifying single-player game "completion." Dots indicate outliers within each category.

7.3.2.2 Completion rates and popularity

The next correlation tested was between completion rates and the number of players according to *Steam Spy*. In general, the more players (Figure 7-13) a game had on *Steam*, the higher the completion rates ($r_s = .16$, $p < .001$, $r_t = .11$, $p < .001$).

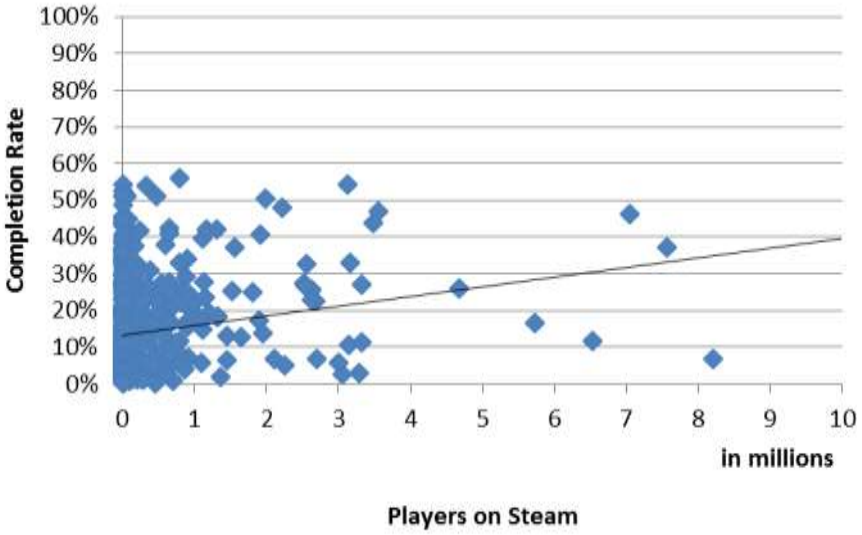

Figure 7-13. The relation of game players on *Steam* to completion rates for games on the *Steam Store* having achievements signifying single-player game "completion."

7.3.2.3 Completion rates and playtimes

The correlation between median playtimes, according to *Steam Spy*, and completion rates was tested. Completion rates tended to rise as the median (Figure 7-14) playtime for games increased, although most games had short playtimes ($r_s = .28$, $p < .001$, $r_\tau = .19$, $p < .001$).

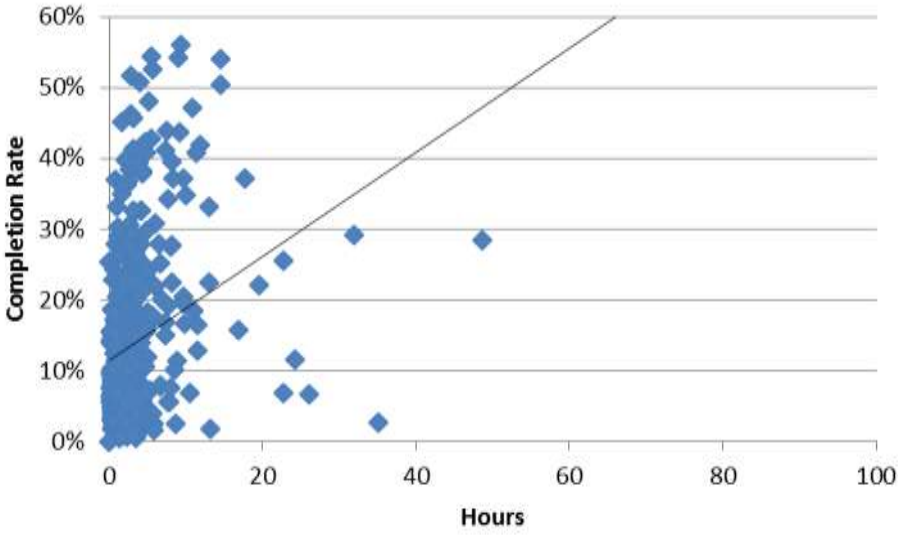

Figure 7-14. The relation of median hours a game has been played, as reported by *Steam Spy*, to completion rates for games on the *Steam Store* having achievements signifying single-player game "completion."

For another perspective on how content volume might correlate with ratings, we tested how longer median playtimes correlated with higher user or *Metacritic* ratings. We assumed that games with very short playtimes (less than one hour) would likely correlate to lower user ratings for one of the following two reasons: players stopped the game early because they were not enjoying it, or the game was so short that it detracted from the player's feeling of satisfaction. We also suspected that shorter games (between one and five hours) could have lower ratings. Given the distribution of median playtimes, and the limited number of games played beyond ten hours, we suspected that ratings for games longer than ten hours would not differ significantly from games in the five-to-ten hour range. User and *Metacritic* ratings for each category are summarized in Table 7-3.

To determine whether the ratings for the different median playtime categories demonstrated significant differences from other categories, two-sample Kolmogorov-Smirnov tests were performed between category samples. When tested, user ratings for games played a median of at least five hours (n = 828) did tend to differ significantly ($D(828,3347) = .12$, $p < .001$) from those of games played between one to five hours (n = 3,347). However, as shown in Table 7-3, the average difference between user ratings of games with median playtimes of one-to-five hours (M = 75%, Mdn = 79%) and greater than five hours (M = 79%, Mdn = 83%) was less than 5%. When games with median playtimes longer than ten hours (n=235) were tested against games in the five-to-ten hour range (n = 593), no significant difference in user ratings was found ($D(235,593) = .03$, $p > .05$).

However, for *Metacritic* ratings, there was still a statistically significant difference in ratings ($D(97,166) = 0.24$, $p < .01$) between games with median playtimes longer than ten hours (n = 97) and median playtimes between five-to-ten hours (n = 166). There was no significant difference in *Metacritic* ratings between games in the 10-to-15 hour range and games with a median playtime longer than 15 hours.

Table 7-3. Summary statistics for user and *Metacritic* ratings for different median playtime ranges.

	User Ratings		Metacritic Ratings	
Median Playtime Range	M (95% CI)	Mdn (IQR)	M (95% CI)	Mdn (IQR)
0 – 1 hour	71% (69 – 72%)	75% (57 – 87%)	69% (67 – 71%)	72% (63 – 78%)
1 – 5 hours	75% (74 – 76%)	79% (66 – 89%)	70% (69 – 71%)	72% (64 – 78%)
5 – 10 hours	79% (77 – 80%)	83% (70 – 92%)	75% (73 – 76%)	76% (68 – 83%)
10 – 15 hours	80% (76 – 83%)	84% (74 – 92%)	78% (76 – 81%)	80% (75 – 84%)
>= 15 hours	77% (74 – 80%)	82% (67 – 92%)	81% (79 – 84%)	83% (76 – 88%)
Overall	75% (74 – 75%)	79% (65 – 89%)	71% (71 – 72%)	73% (65 – 79%)

For a third perspective on how game length might affect ratings, we used data on average single-player, main-path completion times from the website

HowLongToBeat "Main Story" category for all of the games in the completion rate sample and tested the same time frames. (Table 7-4) Only four games had a reported completion time of less than one hour, so that time frame was excluded from the analysis because the sample would be too small to give a statistically meaningful result. Also, the sample covers only the games with completion rates, so the overall mean and median scores differ from those in Table 7-3.

As with median playtimes, we performed two-sample Kolmogorov-Smirnov tests between category samples. For user ratings, there were no significant differences in the ratings between games that were one to five hours and those that were reported as taking longer than five hours to complete. Unlike median playtimes, no trend was found for user ratings rewarding longer single-player main-path content.

However, with *Metacritic* ratings, a similar trend to that found with median playtimes was confirmed. There was a statistically significant difference ($D(55,61) = 0.35$, $p < .01$) between games reported as having a completion length of five-to-ten hours and those with more than ten hours. There was no significant difference in *Metacritic* ratings for games in the 10-to-15 hour range and games with a reported time to complete longer than 15 hours.

Table 7-4. Summary statistics for user and *Metacritic* ratings for different average completion lengths on *howlongtobeat.com*.

	User Ratings		Metacritic Ratings	
Average Length to Complete "Main Story"	M (95% CI)	Mdn (IQR)	M (95% CI)	Mdn (IQR)
1 – 5 hours	82% (79 – 84%)	85% (74 – 91%)	74% (70 – 77%)	75% (71 – 80%)
5 – 10 hours	83% (80 – 85%)	85% (77 – 92%)	75% (72 – 77%)	77% (69 – 81%)
10 – 15 hours	83% (79 – 87%)	84% (77 – 91%)	80% (77 – 83%)	81% (76 – 83%)
>= 15 hours	84% (80 – 87%)	87% (79 – 84%)	83% (80 – 85%)	83% (81 – 85%)
Overall	82% (81 – 84%)	85% (76 – 91%)	77% (75 – 78%)	79% (72 – 83%)

7.3.2.4 Completion rates and pricing

The number of games in the higher price ranges is limited, but there does appear to be a trend for games that cost more money to be completed by more players. (Figure 7-15) Lower priced games tended to have low completion rates, while more expensive games had higher completion rates. ($r_s = .21$, $p < .001$, $r_\tau = .15$, $p < .001$)

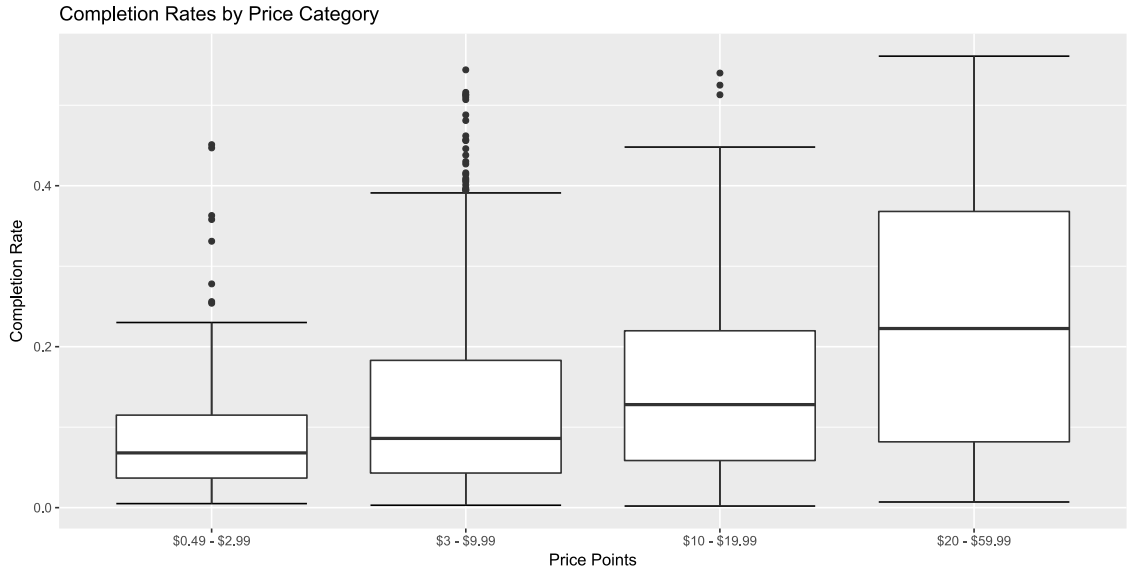

Figure 7-15. The relation of current, non-sale *Steam Store* price to completion rates for games on the *Steam Store* having achievements signifying single-player game "completion." Dots indicate outliers within each category.

The completion rate statistics for each of the price categories is summarized in Table 7-5. Of note is the steady increase in both the mean and the median as the price range rises until there is a difference between a mean of 10% and 23% and a median of 7% and 22%.

Table 7-5. Summary statistics for completion rates in different price ranges.

Price Range	M (95% CI)	Mdn (IQR)
$0.49 - $2.99	10% (8 – 12%)	7% (4 – 12%)
$3 - $9.99	13% (12 – 15%)	9% (4 – 18%)
$10 - $19.99	15% (13 – 16%)	13% (6 – 22%)
$20 - $59.99	23%	22%

	(18 – 28%)	(8 – 37%)
Overall	14%	10%
	(13 – 15%)	(5 – 21%)

The effect of pricing on median playtimes in the sample was also tested. Only the $20 - $59.99 category had a significantly different median play time than the overall sample with a median of 5.8 hours (IQR = 3.8 – 10.3h), which is higher than the overall sample's median of 2.8h (IQR = 1.4 – 4.1h).

7.3.2.5 Completion rates and genre

Genre is one factor that has a strong effect on the nature of the single-player content provided. Many "Adventure" games, for example, will feature a strong linear path, whereas many "RPG" games will offer more optional content, which could affect the likelihood of a player reaching the end of the game.

A test for statistical significance was performed to show which genres could have different completion rates from the overall sample. On *Steam*, each game can be defined by multiple genres. To determine whether any of the genres demonstrated significant differences from the overall sample, two sample Kolmogorov-Smirnov tests were performed for each individual category versus the larger sample. When used to test individual genres against the total sample, "Adventure" ($D(234,643) = .16$, $p < .001$), "Indie" ($D(450,643) = .09$, $p < .05$), "Racing" ($D(21, 643) = .37$, $p < .01$), and "Strategy" ($D(138,643) = .19$, $p < .001$) proved significantly different from the overall sample. The completion rates for these four genres are shown in Table 7-6. Games tagged with the "Adventure" genre tended to have higher completion rates, while games tagged with "Indie", "Racing", or "Strategy" genres tended to have lower completion rates.

Table 7-6. Summary statistics for completion rates of different game genres.

Genre	M	Mdn
	(95% CI)	(IQR)
Adventure	18%	13%
	(16 – 19%)	(6 – 27%)
Indie	11%	8%
	(10 – 12%)	(4 – 16%)
Racing	6%	4%
	(4 – 8%)	(3 – 9%)
Strategy	10%	6%

	(8 – 11%)	(3 – 11%)
Overall	14%	10%
	(13 – 15%)	(5 – 21%)

The effect of genre on median playtimes was also tested. Only games in the "RPG" category had a significantly higher median of 3.8 hours (IQR = 2.5 – 5.7h) than the overall sample's median of 2.8 hours (IQR = 1.4 – 4.1h).

7.3.2.6 Completion rates and release dates

The effect of release year on completion rates was almost insignificant (r_s = -.08, p = .039, r_τ = -.06, p = .036). The expectation was that, with more competing entertainment sources and less time to devote to play, completion rates would drop over the years; however, although there was a slight negative correlation, it was close to being statistically insignificant with both Spearman's rho and Kendall's tau having p values near .05.

7.3.2.7 Completion rates and publishers

In the cases where a publisher had enough games listed on *Steam* to generate a reasonable average (5 or more games), completion rates by publisher were calculated. (Figure 7-16) Some publishers did appear to correlate with higher completion rates, for example *Valve* (N = 7) had an above average completion rate of 32% (95% CI [23%, 41%]) and median of 27% (IQR = 24 – 42%), and *Bethesda Softworks* (N = 7) had a mean completion rate of 30% (95% CI [17%, 43%]) and a median completion rate of 28% (IQR = 27 – 35%). An analysis of variance on the subset of publishers with more than 4 games showed that the effect of the publisher was significant, $F(7,43) = 6.79$, $p < .001$.

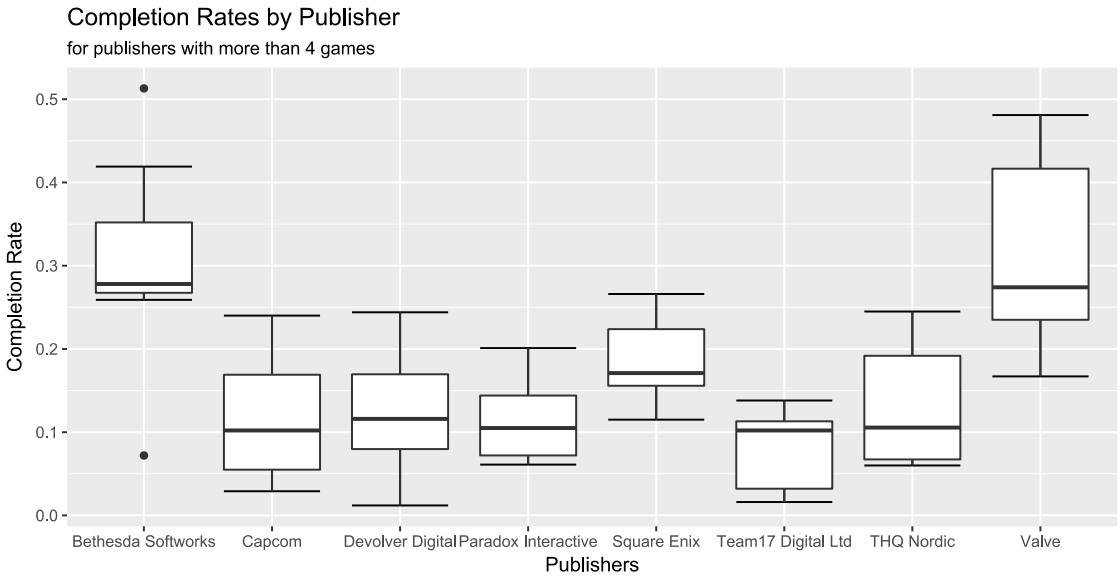

Figure 7-16. The relation between game publishers and completion rates for games on the *Steam Store* having achievements signifying single-player game "completion," for publishers with at least 5 games in the sample. Dots indicate outliers within each category.

7.3.3 Regression analysis of factors related to completion rates

To discover more complex relationships between the various factors investigated and completion rates, multivariate regression analysis was performed. From the factors explored through pairwise correlation tests, *Metacritic* ratings were not included in the analysis because fewer than half the games in the sample have them. Although the correlation with completion rates was stronger with *Metacritic* ratings, user ratings were considered a suitable substitute in the model given that they are strongly correlated with each other. Given the correlations found earlier, we selected user ratings, number of players, price, median play time, and genre as independent variables. Only samples that included all of the factors were included (n = 584). Games can be tagged with more than one genre, so for the purposes of regression, genre was split into individual factors, with a value of 1 if the genre was tagged for a game, and 0 if it was not. The final functional form of the full model was:

$$CompletionRate = \beta 0\ (= BaseCompletionRate) + \beta 1 \log(UserRating) + \beta 2 \log(Players) + \beta 3 \log(MedianPlayTime) + \beta 4 \log(Price) + \beta 5 Genre{:}\,Action + \beta 6 Genre{:}\,Adventure + \beta 7 Genre{:}\,Casual + \beta 8 Genre{:}\,Indie + \beta 9 Genre{:}\,Racing +$$

$\beta 10 Genre{:}\, Simulation + \beta 11 Genre{:}\, Sports + \beta 12 Genre{:}\, Strategy$

The full model indicated above was then reduced to a model representing only factors showing strong significance (p-value < .001). Results for the two models are summarized in Table 7-7.

Table 7-7. Predictors of completion rates for a full model based on all of the parameters and a reduced model based only on user ratings, median play time, and significant genres.

Parameter	Reduced Model	Full Model
BaseCompletionRate	0.20 (15.20)***	0.15 (4.79)***
UserRating	0.06 (4.24)***	0.05 (3.46)***
Players		0.00 (0.66)
MedianPlayTime	0.02 (4.91)***	0.03 (4.99)***
Price		0.01 (1.92)
Genre:Action	-0.03 (-3.49)***	-0.03 (-3.47)***
Genre:Adventure	0.05 (5.53)***	0.05 (5.53)***
Genre:Casual		0.03 (2.44)*
Genre:Indie	-0.08 (-7.58)***	-0.07 (-6.15)***
Genre:Racing		-0.08 (-2.92)**
Genre:RPG		-0.02 (-1.81)
Genre:Simulation		-0.03 (-1.85)
Genre:Sports		0.03 (0.88)
Genre:Strategy	-0.05 (-4.38)***	-0.05 (-4.02)***
R^2	0.27	0.30
Adjusted R^2	0.26	0.28
F	35.02***	18.69***
n degrees of freedom	577	570

* = p <.05, ** = p <.01, *** = p <.001

With this model, a significant regression equation was found ($F(6,577) = 35.02$, $p < .001$), with an R^2 of .27. User rating, median play time, and four genres ("Action", "Adventure", "Indie", and "Strategy") were all significant predictors of completion rates. The final formula based on the reduced model result is:

$CompletionRate = 0.20 + 0.06 \log(UserRating) +$

$$0.02\log(MedianPlayTime) - 0.03(Genre: Action) +$$
$$0.05(Genre: Adventure) - 0.08(Genre: Indie) - 0.05(Genre: Strategy)$$

7.3.4 Outliers with high completion rates

The sample was inspected for games with completion rates several standard deviations higher than the mean. One notable game with an atypically high completion rate (56.1%) compared to the average (14%) was *Telltale*'s *The Walking Dead: Season Two*. A later game in the series, *The Walking Dead: Michonne*, not included in the random sample, was manually checked for a completion achievement and also demonstrated an atypically high completion rate (57.6%). In *The Walking Dead: Michonne*'s case, it is a fairly short game (the *Steam Spy* average playing time is 5.1 hours and the median is 4.2 hours), which partially explains the high completion rate. However, for *The Walking Dead: Season Two*, the reason is not due to length (the *Steam Spy* median play time is 9.4 hours). This rate is also much higher than its first season's completion rate (40.8%). A look at the number of players could explain the rise in completion compared to the first season, however, as *Season Two* only had 794,114 players compared to *Season One*'s 1,918,605. The drop in numbers seems to indicate that the people who purchased and played *Season Two* were likely in the group that had finished the first season, and were therefore more likely to be the kind of players who finished the second season. However, all three of *The Walking Dead* games have much higher than average completion rates. Although it would difficult to determine the causes, some could include: the game is narrative-focused with decisions being the core gameplay – thus skill or puzzle solving is not a central requirement for finishing; the game had earned a lot of attention and word-of-mouth – players knew what they were getting; the game invited conversation – branching decisions meant players could compare stories with other players, possibly motivating completion. Another story-based game by the same developer, *Telltale*, that had a high completion rate was *The Wolf Among Us*, with 55.1%. However, other story-based games by the same developer, such as *Minecraft: Story Mode*, only had a 10.5% completion rate. The average user rating for *Walking Dead: Season Two* was 96%, while for *Minecraft: Story Mode* it was a much lower 65%. The difference in completion rates for the same genre of game from the same developer could either indicate that one game presented a stronger, more engaging experience for players than the other, or, that one game provided a stronger drive to complete it than another – for example, if one game is more popular, it could convince players to complete it for the ability to talk about it with friends.

Wolfenstein: The Old Blood was an example of a skill-based action game that had more than half the players (51.3%) completing the game, so skill-based games can also reach high completion rates. Even with the high completion rate, it had a positive user rating of 83%. The previous game in the series, *Wolfenstein: The New Order* also had a high completion rate (41.9%). The two games vary greatly in length, however, with *The Old Blood* being much shorter than *The New Order*.

Another interesting outlier with an atypically high completion rate is *Ephemerid: A Musical Adventure*, which was the game in the $0.49 – $2.99 price range with the highest completion rate (33%). Priced at $1.99, the game is quite short (*Steam Spy* median play time of 0.9 hours) but is not penalized by its players (average user rating of 90% after 154 reviews) for its length.

7.4 Results of the Completion Rate Analysis

Across the sample, the average completion rate for primary, single-player content in games with achievements marking that state was 14% (95% CI [13%, 15%]). In other words, on average only one in about seven players finish the primary game content. A few exceptions, such as *The Walking Dead: Season Two*, did exist where more than half the players completed the content, indicating that there could be some factors such as the game's design or marketing that can influence this number.

The state of game completion is even more striking when considering the median completion rate of 10%, which indicates that a few games with high completion rates, such as *The Walking Dead* games, pull the average completion rate higher. In fact, the interquartile range shows that half of games have completion rates between 5% and 21%.

For these projects, particularly the ones on the lower end, resources were spent creating content that only a minority of players experience. The result is that time and money has been spent creating something the developer's target consumers do not value.

7.4.1 Factors correlated with completion rates

Completion rates were correlated with several other factors. For example, a correlation was found between higher completion rates and "higher quality", as determined by both professional critic reviews and user reviews of the game. Players were more likely to have completed games that had higher ratings. The *Telltale Games* example mentioned among the outliers, which compares the above 50% completion

rates of their "highly rated" games to the 10.5% completion rate of one of their "poorly rated" games supports this trend. The fact that high completion rates are not correlated to lower reviews but to higher reviews seems to indicate that if a developer had to choose between devoting resources to content quality or content quantity, quality is the better choice.

There is also a noticeable correlation between completion and popularity, as measured by the number of players a game has on *Steam* – the more popular a game, the more likely it is to have a higher completion rate. However, causation would be much more difficult to determine in this case, as popularity can be related to factors outside of the game content itself – word of mouth and critical mass, or marketing efforts, for example. Also, a developer cannot easily predict how well their game will sell, so this correlation may not be so useful in the decision-making process.

Although it reflects content, such as multiplayer or optional content, not necessarily related to the completion of the main-path, single-player content, median playtime was positively correlated to completion rates, which could indicate the player falloff patterns found with playtime are going to occur with completion rates as well. In addition to the presence of multiplayer, the style of game is likely to influence how the median playtime correlates to the completion rate. The median playtime of 3.8 hours for the "RPG" genre was found to be higher than the 2.8 hours for the overall sample, despite the completion rate not differing significantly from the overall sample.

Pricing was another factor positively correlated with completion rates. Games in the budget range of $0.49 – $2.99 only had a mean completion rate of 10% versus 23% for games in the high price range of $20 – $59.99. The median values are even farther apart, with a median completion rate of 7% for budget games and 22% for high priced games. One possible explanation for this difference is that games that are able to charge a higher price could have larger budgets behind them and thus, could provide a more engaging experience to their players. Also, games that are priced higher tend to be newer releases, so less enthusiastic players waiting for sales may not have yet purchased and played the game. There could also be psychological "sunk cost" factors involved, as players who have spent over $20 might be more motivated to finish the game they purchased and "earn value for their money" versus when they spend less than $3 on a game. (Arkes and Blumer, 1985, Gourville and Soman, 2002, Thaler, 1980) Playtimes also reflect the increased player engagement with higher priced titles. Median playtime for games in the $20 - $59.99 range was 5.8 hours compared to 2.8 hours for the overall sample. Both the completion rates and playtimes indicate that, for

a developer with a larger budget seeking a higher price point, players are likely going to be expecting more content than they would from a budget title.

Strong correlations were found between completion rates and four genres, with "Adventure" games being on the high end and "Indie", "Racing", and "Strategy" games being on the low end. "Indie" games tend to be priced lower, however, so some of this correlation may tie in to pricing effects on completion rates. For "Adventure" games, both the mean of 18% and median of 13% were higher than games in the overall sample, and the genre includes some of the most completed games in the sample. One possible explanation is that the adventure genre does not always demand the high reflexes or game-based skill that other genres might require, which allows more players to complete the content regardless of their video game playing skill. Another explanation could be that they tend to feature more linear content than other genres, making it less likely for players to stray from the single-player mode's main-path.

Strong correlations were also found between completion rates and some publishers, with companies like *Valve* or *Bethesda Softworks* capable of keeping many more of their players to the end of their games than the average. Also, *Telltale Games* has at least two examples of games with the highest completion rates found in the sample, both exceeding a completion rate of 50%. While these are both linear adventure games, they are still far above the mean for the overall "Adventure" genre.

Surprisingly, the release year had a negligible effect on completion rates. Given that players are being presented with more options for seeking entertainment, our assumption was that completion rates would drop year-by-year; however, this was not the case. Although there was a slight negative correlation, the correlation was almost insignificant and seems to indicate that release year does not have that strong of an effect. One factor that could be hiding a correlation is that more recent releases tend to be priced higher, so even if later games have fewer players reaching the end of their content than earlier games, this trend could be hidden by other, stronger trends. As the entertainment industry evolves, it would be worth keeping an eye on this correlation, as changes could dramatically impact the way people play games.

Multivariate regression analysis revealed that, when factors are taken together, ratings, play time, and four genres ("Action", "Adventure", "Indie", and "Strategy") can be used to some extent to predict completion rates. As in the pairwise correlations, a rise in user ratings or median play time leads to a higher completion rate. Also, as with the basic correlation test, for genre, games tagged with "Adventure" tend to have a higher completion rate, while games tagged with "Action", "Indie", and "Strategy" genres tend to have lower completion rates.

7.4.2 Content scope recommendations to video game project owners

Based on the results of this research, most players are not finishing the single-player content in the games they play on *Steam*. Also, no negative correlation was found between high completion rates and user or critic ratings.

When considering the overall median playtime for games in the sample is 2.8 hours and that only 5% of games have a median playtime longer than ten hours, longer playtimes may not provide much additional value for the majority of users. There was no significant statistical difference in user ratings between games with median playtimes of 5 – 10 hours and more than ten hours, and the average difference in user ratings for games with median playtimes between 1 – 5 hours and 5 – 10 hours was less than 5%. Even more relevant to completion rates, there was no significant statistical difference between user ratings and the length of single-player main-path content completion times reported on *HowLongToBeat*.

Even games in the high-end $20 - $59.99 range only had a median playtime of 5.8 hours, and games in the content-heavy "RPG" genre only had a median playtime of 3.8 hours. Outliers such as *Telltale's The Walking Dead* do indicate that, if the game experience is positive, players will still favorably value the product even if it provides a shorter experience with the resulting high completion rates.

Video game development budgets are rising, but there could be room for developers to reconsider whether the amount of resources they are investing in single-player content generation is of value to their users. In any production process, there will always be a decision to make regarding quantity versus quality. From the results of this research, it seems prudent to lean towards quality over quantity if the goal is to satisfy consumers and generate business returns.

7.4.3 An example of the research concept applied to a project

Although completion rates are only an indicator of how many players have completed the main-path single-player content in previously released games, they can provide a benchmark for future scoping decisions in individual projects. While this research provided an overall view of completion rates across games on the *Steam* platform, with divisions by categories such as price and genre, it is possible to focus on specific case examples similar to the project in question for estimating how much content is required. While this research focused on *Steam* achievements because of the

availability of the data set, the same principles can be applied to games on other platforms.

One of the researchers was involved in initiating a virtual reality (VR) project and used the following method to determine a target gameplay length. Originally, the project design called for eight hours of content; however, the team was small, and resources were limited, so developing the amount of content required for an eight-hour experience had the potential to impact quality. There was also concern that virtual reality titles may not require as much length as other console titles.

Similar games to the one proposed, based on genre and target audience, were chosen for investigation. In particular, the *PlayStation* platform VR game, *Farpoint*, served as a benchmark. *Farpoint* contained a trophy achievement, "Survivors Never Die" indicating completion of the primary game content, and 19% of users had obtained it. The typical amount of playtime required to complete the game was investigated through websites, such as *HowLongToBeat*, and the figures reported were roughly five hours for the main path content and seven hours for main and side content. The statistic was reconfirmed as a reasonable estimate with developers who had played the game.

The costs for developing content in the proposed project were high enough that a completion rate, similar to *Farpoint*, of at least 20% was desired, with the assumption that at least one-in-five users finishing the game would reasonably justify the content while leaving the game long enough to provide a satisfying experience. Based on the *Farpoint* completion rate and main path gameplay statistics, the design was modified from the original eight hours to five hours, with an emphasis on using resources to maintain the quality of the shorter experience.

Although this is just one example, a similar process can be employed using the achievement statistics of prior, similar games to determine a reasonable amount of content to provide.

7.4.4 Limitations to the analysis

Some limitations to this research are: the focus on main-path single player content, the focus on PC games released digitally on *Valve Corporation*'s *Steam* platform, and a focus on correlation over causality.

This research only analyzed achievements that indicate the end of the main-path, single-player game. This excludes multiplayer content and optional content, such as downloadable expansions or side quests, which could provide the bulk of experience in games like "sandbox" games or "RPG"s. Our research also excluded

achievements that were dependent on difficulty conditions, such as requiring the player to complete the game on "normal" or higher difficulty as opposed to any difficulty. There is always the possibility that completion rates could differ for games that force players to choose higher difficulty modes for obtaining achievements, and without an achievement to signify completion at the easier difficulty, there is no way to count the ratio of players who finish the game on the easier mode.

Also, the nature of games or players on the *Steam* platform could differ from that of other platforms, such as *Sony*'s *PlayStation*, *Microsoft*'s *Xbox*, or *Nintendo*'s *Wii* and *Switch* hardware. In particular, all games on *Steam* are digital downloads, so completion rates could differ from games purchased on a physical medium. Also, the research focused on games that require money to purchase, which excludes "free-to-play" (F2P) games. Content usage will still be an issue for those games, but the business model involved is different enough to warrant a separate investigation, particularly with regard to mobile games, such as ones released on *Apple*'s *App Store* or *Google*'s *Play* platforms.

Finally, one limitation present in any research that focuses on correlations between factors is that causation cannot be determined – an independent third factor may be the cause of both conditions, for example. Although an experiment could be designed to focus on causation, our research focused on insights that could be obtained from examining the existing game market.

7.5 Implications for Video Game Content Scope Decisions

This research analyzed video game completion rates using achievement data from a sample of 725 games on *Valve Corporation's Steam* service and found that, for most games, only a minority of players (M=14%, Mdn=10%) finish the games they start.

Correlations between completion rates and other factors, such as user and *Metacritic* ratings, number of players, median playtime, price, genre, release date, and publisher were analyzed individually and together through regression testing. Significant positive correlations were found between completion rates and both user and *Metacritic* ratings, the number of players, median playtime, price, genre, and publisher, while the correlation to release date was found to be negative but nearly insignificant. When the factors were analyzed together, linear regression analysis showed that user rating, median play time, and four genres ("Action", "Adventure", "Indie", and "Strategy") were all significant predictors of completion rates.

Some significant outliers with high completion rates such as *Telltale*'s *Walking Dead: Season Two* and *Wolfenstein: The Old Blood* had positive user ratings despite the majority of players finishing the main-path single-player content.

The majority (95%) of games in the sample are only played for a median of ten hours or less, so users may not value the presence of additional content as much as they value other factors like quality, and reducing content scope does not necessarily imply a reduction in value for consumers. Even in cases where players might be expecting more content based on a higher price tag or an RPG-genre game, the median playtimes indicate that they might not need that much additional content compared to other games.

Knowing "how much game is enough" is an important question to answer when determining the requirements for a video game in the planning phase, especially given that decisions or changes made in the planning phase are likely to be far less costly than decisions or changes made later in the process. Whether 14% of players completing the single-player content in a game is enough to justify its creation is up to the developer's goals with the content and the costs involved in production versus the number of sales. For developers with strong toolsets, low costs for content creation, and high sales numbers, even having 1% of players using the content could justify its creation; for developers with narrative-heavy games that require extensive computer graphic work, even 30% of players using the content may not be enough to justify the cost of its creation.

Striving to meet consumer needs and using data to assist the decision process are critical to the success of any business. Amidst growing project budgets and competition, video game businesses must monitor the way their content is consumed and work to update their understanding of player needs. Only by doing this can they ensure they are investing resources in areas that genuinely create value for their consumers.

7.6 Utilizing KDD with External Data to Verify Decisions Regarding the Value of Product Content Scope in the Video Game Industry

The research presented in this chapter employed KDD techniques to quantify content consumption trends in video games to provide the first part of the answer to the question:

- How do the product scope decisions made in video game project management reflect what provides value to consumers?

Given the limited budgetary resources for developing a video game project, organizations must decide what product content scope will strike the optimum balance between content volume and quality for their target consumers if they want to make the best use of those resources. The benefits of the knowledge gained through employing a KDD technique such as the one presented to decision-makers deciding "how much game to make" is the ability to rationally analyze product content scope decisions and justify those decisions to other stakeholders within an organization. Understanding the likelihood that a consumer will consume and therefore receive value from the planned content of a game allows product owners and project managers to weigh the costs of developing that content against the expected benefits of providing that content to consumers. (Figure 7-17)

Although industry-wide level data was employed, a specific case of the technique was demonstrated where the comparison was made to similar video game products that had been released in the past in order to avoid spending development resources on content that was unlikely to provide value to more than a minority of players.

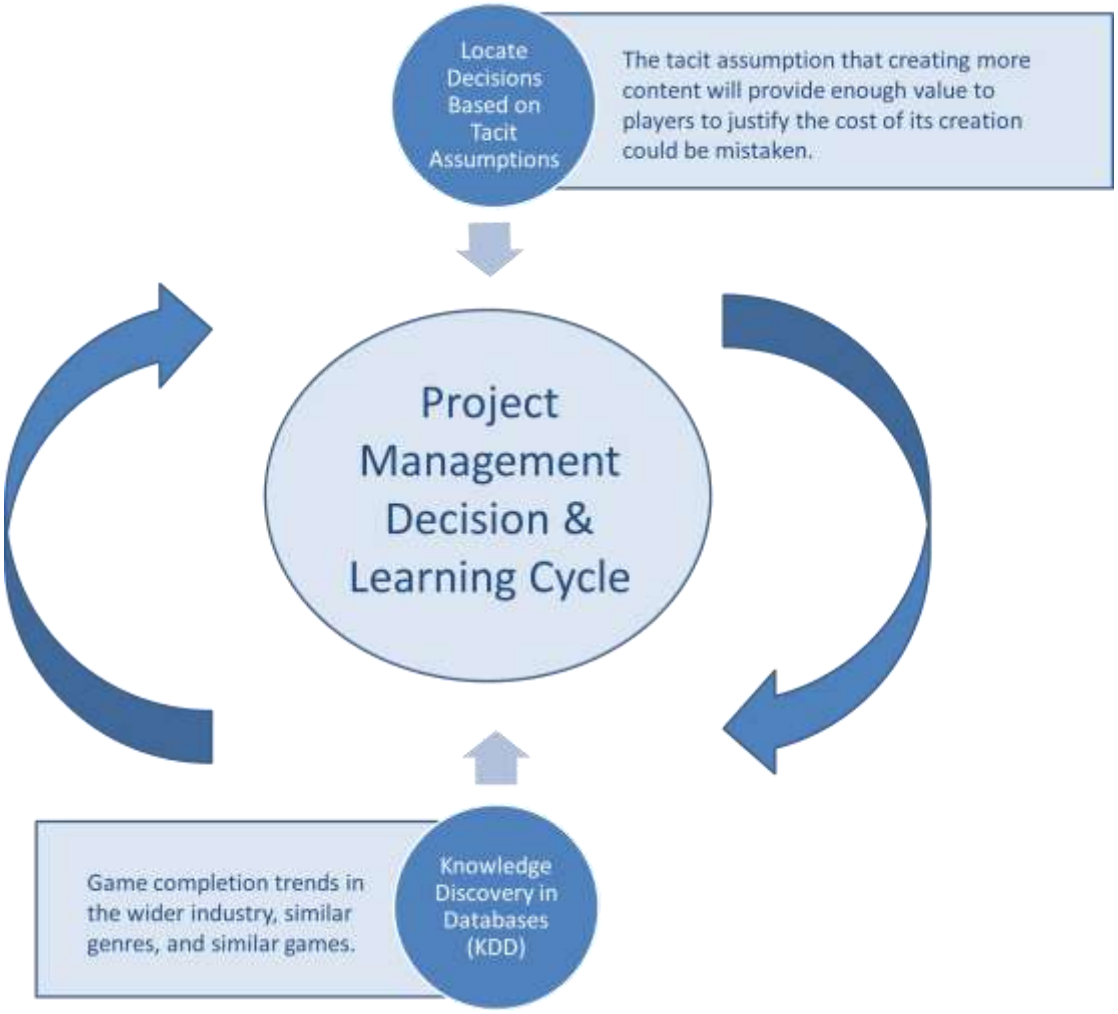

Figure 7-17. Incorporating publicly available Steam achievement data to validate or position assumptions regarding the amount of content players value in their games.

8. An Analysis of a Functional Scope Decision in Video Game Projects

In Chapter 8, I analyze the other component of product scope decisions made for video game projects with an example of functional scope. The research is the second part of the answer to the question:

- How do the product scope decisions made in video game project management reflect what provides value to consumers?

As with the content scope research, data from the largest retailer of PC games, *Steam*, serves as the basis for knowledge discovery. One example of functional scope is including the ability to play with other players over a network, or "multiplayer." However, a problem with including multiplayer is that it is costly to develop, especially if the decision to include it is made later in the project. The research presented in Chapter 8 uses data mined from *Steam* and other sources to find how the inclusion of a multiplayer function impacts sales and ratings as well as how often it is used by players to help video game directors and producers to make better decisions.

In this research, we examine one of the most time and resource intensive functional scope decisions: whether to include a multiplayer feature within a game. Through analyzing the sales and critical results of 34,263 applications on *Valve Corporation*'s *Steam* PC game service, we provide decision makers with insight into the value including multiplayer can add to a video game project.

8.1 Functional Scope in Video Game Projects

"Managing the project scope is primarily concerned with defining and controlling what is and is not included in the project." (Project Management Institute, 2017, p. 129) Scope can impact quality and the ability to deliver a game project on schedule. (Washburn et al., 2016) Scope in video games includes both functional scope – the unique features and systems available in the game – and content scope – the amount of content provided with the game. In particular, one aspect of functional scope that has the potential to increase the amount of time and cost required to develop a video game project is an online multiplayer feature. Games need to be built with

multiplayer in mind from the beginning, as the entire game may need to be designed for it, and later implementation can force developers to rework much of what has already been made.

Including a multiplayer feature brings many potential benefits, but it comes with many drawbacks as well, particularly the expense involved in developing and maintaining an online mode. Even when resources go into developing multiplayer, not all of the features are used by the majority of players. (Hullet et al., 2011, Hullet et al., 2012) Within the game console market, prior research noted that, because of the need for an active community, multiplayer can be a valuable addition to the game towards the end of a console's life cycle, when there are enough players to justify it, while a single player focus can be a stronger strategy earlier in the console life cycle. (Marchand, 2016) However, for PC games, the life cycle dynamics that dominate the console market are not present. Of the many PC game retail outlets, Valve Corporation's digital distribution platform, *Steam*, dominates the market with 18.5 million concurrent users in January 2018. (xPaw and Marlamin, 2018)

Lacking an online community can negatively impact perceptions of a video game, but another factor outside of developers' control, latency, has also been found by research to negatively impact perception. (Dick et al., 2005) Even if a game can gather an online community, social issues with other players ranging from cheating to community norm violations to "griefing" or harassment can negatively impact player experiences with multiplayer content. (Smith, 2004) Most of these negative aspects are outside developer control. There are positives and negatives to including online multiplayer functionality, so a more data-informed approach could help product owners decide early in the development process whether to pursue an online strategy or to focus resources on the single-player game.

8.2 Analyzing Functional Scope Decisions Using Knowledge Discovery in Publicly Available Databases

For this research, data mining of web-based sources is used to derive insights that could be helpful for video game businesses. We also introduce a technique that could be used to determine multiplayer usage through examining video game "achievements" on a limited sample.

The principle research question that we are attempting to answer is whether the inclusion of a multiplayer feature is worth the development effort.

- Is the inclusion of a multiplayer feature worth the development effort?

We hypothesize that the inclusion of multiplayer has a positive impact on sales because it adds to the utility of a video game for players; however, we also hypothesize that the additional demands required for a positive multiplayer experience will have a negative impact on user ratings. We also hypothesize that this impact will not be felt as strongly in professional critic ratings because critics are testing the game in a more ideal, pre-release environment. Finally, we hypothesize that the multiplayer features of games that focus on single-player content are not used by the majority of players.

- Does the inclusion of multiplayer have a positive impact on sales?
- Does the inclusion of multiplayer impact user ratings and professional critic ratings?
- Are the multiplayer features of games that focus on single-player content used by the majority of players?

8.2.1 Focus of functional scope analysis

The sample used in this research includes games (PC, Mac, Linux) released on *Valve Corporation's Steam* service from its inception to early 2017. More recent data was not included because it could contain games that are still selling or receiving reviews.

The *Steam* service was chosen for three reasons: first, it is the most popular online PC game retail and digital distribution platform; second, much of *Steam*'s data is publicly available, so it is more suitable for large-scale sampling; third, the service is a fully digital distribution platform for the PC, so it is not subject to game console lifecycles.

8.2.2 Publicly available data sources

The primary source of data used in this research is data made publicly available for video games released on *Valve Corporation's Steam* service platform. This data

includes aggregated professional critic scores from *Metacritic.com*. In addition, data from Sergey Galyonkin's *Steam Spy* and "xPaw" and "Marlamin's" *SteamDB* was employed for estimating the number of owners for each game.

Steam's Top Sellers of 2017 list (Valve Corporation, 2018), which is divided into "Platinum", "Gold", "Silver", and "Bronze" categories by gross revenue, and *The NPD Group's* top-ten best-selling games of the year lists from 2001 to 2017 were gathered from multiple video game news sites and used to find examples of the best-selling games on both *Steam* and video game consoles.

8.2.3 Data transformations

The list of all applications on *Steam* was obtained from its application programming interface (API), available from the link: http://api.steampowered.com/ISteamApps/GetAppList/v0001/. The unique AppID identifier was used as a base for collecting information from *Steam Store* pages for each game using *Python* to generate links of the form: http://store.steampowered.com/app/(AppID). These store pages included tagging information that could be used to identify whether *Valve* had labeled the game content "Single-player", "Multiplayer", and/or "Co-op" as well as the *Metacritic* score and *Steam* user rating – both as percentages. The same AppID was used with *SteamDB*, using a link of the form: https://steamdb.info/app/(AppID) to gather *Steam Spy* owner data for the games in the sample.

Many of the applications with AppIDs were not game applications and needed to be remove from the data set. This was done by only including entries that had either a "Single-player", "Multiplayer", or "Co-op" flag. Also, games without a release date were removed from the sample as they could indicate unreleased games or incomplete data. This reduced the sample from 34,263 to 19,621 (57% of the total). Games with either a "Multiplayer" or a "Co-op" flag were combined into one multiplayer category.

8.2.4 Data modeling

Means (M) with 95% confidence intervals (95% CI), medians (Mdn) with interquartile ranges (IQR), and maximums were calculated for owner counts, *Metacritic* scores, and user ratings of the total sample as well as for each category.

Two categories were created for sorting *Metacritic* scores and *Steam* user ratings based on *Metacritic's* game sorting: Favorable (>= 75%) and Unfavorable (<

75%). (Metacritic, 2018) Statistics for each category were also calculated and analyzed for possible differences in trends between unfavorably and favorably rated games.

The data could not be expected to be normally distributed, so to determine whether the number of owners, *Metacritic* scores, and user ratings for single-player, multiplayer, single-player only, and multiplayer only games differed significantly from those of the overall sample population, a Wilcoxon rank-sum test was performed on each binary factor because it does not assume a normal distribution.

8.2.5 Outlier testing

To discover outliers for further analysis, examples at the extremes for each of the categories were examined. In addition, *The NPD Group's* top-ten best-selling games of the year lists for the period from 2001 – 2017 and *Steam*'s Top Sellers of 2017 list were used to find examples at the top-selling end of the video game spectrum.

8.2.6 Multiplayer achievement analysis

As the results in Hullet et al. (2011) suggest, different aspects of multiplayer might be more utilized by players than others. In Chapter 7, achievement data was used to analyze the utilization rates of single-player content. For this research, *Steam* achievements were analyzed for single-player games with multiplayer modes from the "Platinum", "Gold", and "Silver" categories of *Steam's* Top Sellers of 2017 list to discover trends in player utilization of multiplayer functionality and modes in games with single-player content. Not all games have achievements related to multiplayer usage, but several cases were found in *Steam's* list.

8.3 Multiplayer Functionality in Video Games on *Steam*

Of the 19,621 games in the sample, 18,220 games (93%) were tagged by *Steam* as "Single-player", 6,312 games (35%) were "Multiplayer", and 5,071 games (26%) were "Co-op". "Multiplayer" and "Co-Op" games were combined for a total of 8,285 games (42%) with multiplayer functionality. Games can be tagged in more than one category; only 11,336 games (58%) were single-player only and 1,401 games (7%) were multiplayer only.

Steam's Top Sellers of 2017 list is divided into four tiers based on gross revenue: "Platinum", "Gold", "Silver", and "Bronze". In the Platinum tier, only one game, *The Witcher III*, was single-player only. However, single-player only games represent

roughly a third of games in the remaining tiers. The distribution of game types is listed in Table 8-1.

Table 8-1. The number of games in each category of *Steam's* Top Sellers of 2017.

Category	Single-Player Only	Multiplayer Only	Both
Platinum	1	4	7
(n = 12)	(8%)	(33%)	(58%)
Gold	4	1	7
(n = 12)	(33%)	(8%)	(58%)
Silver	5	5	4
(n = 14)	(36%)	(36%)	(29%)
Bronze	18	4	34
(n = 56)	(32%)	(7%)	(61%)
All	28	14	52
(n = 94)	(30%)	(15%)	(55%)

8.3.1 The relation between a multiplayer function and video game sales

The first relationship tested was between the presence of single and multiplayer functionality and sales. (Table 8-2) This was done by examining the *Steam Spy* estimated owner counts for entries with the three flags. 4,943 samples had *Steam Spy* owner counts. The most owned multiplayer game in the sample was *Counter-Strike: Global Offensive* with 30.6 million owners, while the most owned single-player game in the sample was *Half-Life 2* with 9.9 million owners.

Table 8-2. The average number of owners for single and multiplayer games on *Steam* (in thousands).

Type	M (95% CI)	Mdn (IQR)
Single Player	146K	23K
(n = 4,816)	(132 – 160K)	(7 – 104K)
Single Only	117K	21K
(n = 3,508)	(104 – 130K)	(6 – 89K)
Multiplayer	267K	32K
(n = 1,435)	(206 – 329K)	(9 – 167K)
Multi Only	722K	24K

(n = 127)	(157 – 1,286K)	(5 – 186K)
Single & Multi	223K	33K
(n = 1,308)	(185 – 262K)	(9 – 163K)
All	161K	24K
(n = 4,943)	(141 – 181K)	(7 – 106K)

The mean number of owners for multiplayer (M = 267K) and multiplayer-only (M = 722K) games was higher than the overall sample (M = 161K) and much higher than single-player only games (M = 117K). However, median sales showed a different trend, with games having both single and multiplayer modes (Mdn = 32K) being higher than the overall sample (Mdn = 24K). The presence of a few hit multiplayer-only titles likely pushed the mean high, but the median owners for multiplayer-only games (Mdn = 24K) was similar to that of the overall sample (Mdn = 24K).

Across the categories, a low median compared to the mean indicates a strong right skew, which could be expected given the "hit" nature of the video game business – a few highly owned outlier titles pull the mean higher.

A Wilcoxon rank-sum test on the presence of multiplayer showed a statistically significant difference ($p < .001$). Subdividing the data into "Favorable" and "Unfavorable" user rating and *Metacritic* score categories did not affect the results.

8.3.2 The relation between a multiplayer function and critical ratings

The next relationship tested was between the presence of single and multiplayer functionality and *Metacritic* scores. (Table 8-3) Only a subset (n = 2,506) of games have enough professional reviews to have a *Metacritic* score.

Table 8-3. The average *Metacritic* scores for single and multiplayer games on *Steam*.

Type	M (95% CI)	Mdn (IQR)
Single	72%	74%
(n = 2,417)	(72 – 73%)	(66% - 80%)
Single Only	72%	73%
(n = 1,449)	(71 – 72%)	(66% - 79%)
Multiplayer	73%	75%
(n = 1,057)	(72 – 74%)	(66 – 81%)
Multi Only	73%	76%
(n = 89)	(70 – 76%)	(67 – 82%)

Single & Multi	73%	75%
(n = 968)	(72 – 74%)	(66 – 80%)
All	72%	74%
(n = 2,506)	(72 - 73%)	(66 – 80%)

The mean *Metacritic* scores are similar across categories, but the median was slightly higher for games with multiplayer (Mdn = 75%) and multiplayer-only (Mdn = 76%) versus the overall sample (Mdn = 74%). A Wilcoxon rank-sum test on the presence of multiplayer on *Metacritic* scores indicated that its presence did result in a statistically significant difference ($p < .001$) from the overall sample.

After subdividing the data into "Favorable" and "Unfavorable" *Metacritic* score categories, the effect of multiplayer presence on *Metacritic* scores was no longer statistically significant for Unfavorable (*Metacritic* score < 75%) games.

The third relationship tested was between the presence of single and multiplayer functionality and *Steam* user ratings. Given that users can rate all of the games on *Steam*, the sample available for testing user ratings is larger than the critic sample. Of the 19,621 games in the sample, 16,189 have user ratings associated with them. However, a majority of games have only a few reviews attached to them. To avoid overweighing games with few reviews, only games with more than 30 reviews were used for testing. This left 7,893 samples for testing. The results are shown in Table 8-4.

Table 8-4. The average user review scores for single and multiplayer games on *Steam*.

Type	M (95% CI)	Mdn (IQR)
Single	75%	79%
(n = 7,470)	(74 – 75%)	(65 – 89%)
Single Only	75%	79%
(n = 4,914)	(74 – 75%)	(65 – 89%)
Multiplayer	73%	76%
(n = 2,979)	(72 – 73%)	(62 – 87%)
Multi Only	65%	66%
(n = 423)	(63 – 66%)	(53 – 80%)
Single & Multi	74%	78%
(n = 2,556)	(73 – 75%)	(64 – 88%)
All	74%	78%
(n = 7,893)	(74%)	(64 – 88%)

The user rating was slightly lower for multiplayer games (M = 73%, Mdn = 76%)

and much lower for multiplayer-only games (M = 65%, Mdn = 66%) versus other categories. To test whether this effect held for popular games with more owners, the means and medians were checked for games with more than 100K owners. While the average user ratings rose (n = 464, M = 74%, Mdn = 78%) for multiplayer games, the average also rose for the overall sample (n = 1,215, M = 77%, Mdn = 81%), and the difference remained.

A Wilcoxon rank-sum test on the single-player flag indicated that the presence of single-player resulted in a statistically significant difference ($p < .001$) in user ratings from the overall sample. The presence of multiplayer also resulted in a statistically significant ($p < .001$) difference. However, when the data was divided into "Favorable" (user rating >= 75%) and "Unfavorable" (user rating < 75%) groups, there was no longer a statistically significant difference for the presence of multiplayer in "Unfavorable" games.

8.3.3 The usage patterns of multiplayer functionality by players

Although it is not possible to make statistically significant judgments based on a limited sample, we examined a few cases of how many players took advantage of multiplayer features when they were included in single-player games. The achievement data for games with multiplayer modes in the Platinum, Gold, and Silver tiers of *Steam*'s Top Sellers of 2017 list was inspected for indications of multiplayer feature usage in games with single-player content.

In the Platinum tier, *Divinity: Original Sin 2* contained a co-operative play mode that could optionally be used throughout the game's campaign, but it also released two special modes for use with other players. One mode, "Game Master", allowed a player to design and host a game for others. The "Gather Your Party" achievement showed that only 4.2% of players tried the Game Master mode. The other mode, Arena, gave players a chance to fight each other. The achievement "Venture Forth" showed that only 3.5% of players began a match in this mode.

Within the Gold tier, the game *Total War: Warhammer* has both single and multiplayer modes, but the achievement "Up For A Scrap" showed only 27.5% of players started a multiplayer battle, with "Armchair General" indicating 18.7% continued to play for at least five battles and "Armchair Emperor" indicating that 7.5% continued to play for 25 battles. *Total War: Warhammer* also had a longer multiplayer campaign mode. "A Confrontational Nature" showed 23.1% of players participated in a multiplayer campaign, while "First Among Equals" indicates only 2.9% went on to win

it. Within the Silver tier, the sequel, *Total War: Warhammer II* demonstrated a similar pattern of use. "Spoiling for a Fight" indicated 26.3% of players participated in a multiplayer battle, while "First Among Equals" indicated 10.9% remained for 10 multiplayer battles. "A Taste for Glory" showed 22.4% participated in a multiplayer campaign.

Another game in the Gold tier, *Civilization VI*, also has both single and multiplayer modes. The "Land Party" achievement showed that 28.6% of players participated in at least one multiplayer game.

In the Silver tier game *XCOM 2*, "The Most Dangerous Game" indicated only 2.0% of players went on to win a multiplayer match. In another Silver tier game, *Path of Exile*, players could join up with up to six others. "Band Together" showed 13.6% of players joined a party. However, another game mode, "Capture the Flag", was less popular; only 0.8% of players captured a flag according to the statistics for the "Capture the Flag" achievement.

8.3.4 Outliers with no multiplayer functionality

Although there may be a perceived pressure that online multiplayer is required in the current market to succeed, there are examples of single-player only games that have sold well. Three examples of console games without online multiplayer features from *The NPD Group's* top-ten best-selling games of 2017 list were: *Nintendo's Super Mario Odyssey*, *The Legend of Zelda: Breath of the Wild*, and *Ubisoft's Assassin's Creed: Origins*. In the latter case, previous installments of the *Assassin's Creed* series featured online multiplayer, so it is notable that it was not included in the most recent game.

Also, *The Witcher III* made Steam's Top Sellers of 2017 highest "Platinum" category despite having only a single-player experience. Although *The Witcher III* was the only example in the "Platinum" gross revenue list, roughly a third of games in the "Gold" (4 out of 12), "Silver" (5 out of 14), and "Bronze" (18 out of 56) were single-player only experiences.

8.4 Results of the Multiplayer Functional Analysis

The data indicates that games including an online multiplayer feature tend to do better in sales than games without one. As one goal in implementing a multiplayer feature is to create a hit, it is important to consider both the mean, even if it is sensitive to outliers, and the median values. In particular, the "owners" ceiling is much higher for the best-selling outliers, which results in a mean of 117K owners for single-player only

games versus a higher mean of 223K owners for games with a single-player mode and a multiplayer mode. The median values are closer, with 21K for single-player only games versus 33K for games with both modes.

Also, although there are some notable exceptions, most of the games in *Steam's* Top Sellers of 2017 list and *The NPD Group's* top-ten best-selling games of 2017 list do have online multiplayer. However, even if games with multiplayer tend to sell better, the sales numbers may not justify the development risks and expenses involved.

8.4.1 The benefits and disadvantages of including a multiplayer function

One important observation to make is that every example of a best-selling game, in both *The NPD Group's* top-ten best-selling games of 2017 list and the "Platinum" and "Gold" categories of Steam's Top Sellers of 2017 list, without online multiplayer contained a significant volume of single-player content. For developers aiming for a top-selling hit, the question comes down to whether it is better to devote resources to expanding functionality by adding online multiplayer, and risk diluting the single player experience, or by expanding or improving the single-player content. However, adding single-player content is expensive, and, as was demonstrated in Chapter 7, may only add value for a limited number of players. *Cuphead* and *Resident Evil VII*, two examples from the "Silver" category, do show that games with a more compact single-player experience still have the potential to sell well. However, the lack of shorter, more linear single-player experiences from the top of both lists does seem to indicate that it is unlikely for such a game to reach the top. A developer either has to focus on creating a strong multiplayer experience or an open, expansive single-player experience – both of which are development resource-intensive, high-risk, high-reward options.

From a ratings perspective, based on *Metacritic* scores, there is no significant advantage to critical reception for including an online multiplayer feature. However, when it comes to user ratings, the data showed that games including online multiplayer tended to fare worse than single-player games. This is likely due to user reactions to a range of issues, such as player and connectivity issues, and inspection of negative user reviews for games with multiplayer features supports this could be the case. An absent online community could certainly impact the multiplayer experience, but the data showed that popularity is not the only issue; even for games with more than 100K owners, user ratings were lower for games with multiplayer than games in the overall sample. This seems to indicate that the inclusion of multiplayer will tend to result in lower user ratings, possibly due to issues outside of the developer's control.

Some games with a single-player focus but some multiplayer features did have a significant portion of players trying the multiplayer content. *Total War: Warhammer I* and *II* as well as *Civilization VI* had more than a quarter of its user base trying multiplayer. However, only roughly a tenth of players continued to use the multiplayer features in *Total War: Warhammer II* for at least ten matches, indicating the fall-off could be steep in some cases.

In games with strong single-player content, multiplayer may not be necessary. In one example from the limited achievement sample, *XCOM 2*, only 2% of players won a multiplayer match against other players online, which indicates few players obtained utility from the multiplayer functionality.

8.4.2 The option of reducing multiplayer functional variety

Even if the decision is made to include online multiplayer, reducing the amount of variety to focus on more popular modes is an option for controlling development costs without reducing the utility provided to players. When analyzing data from *Microsoft's Xbox 360* racing game *Project Gotham Racing 4*, Hullet et al. (2011) found that 30 - 40% of the content in the features they analyzed was used in less than 1% of races, 12 of 29 event types were used less than 1% of the time, and 50 out of 134 unique vehicles were used in less than 0.25% of races.

One example from this research, *Path of Exile*'s "Capture the Flag" mode was used by less than 1% of players. In *Divinity: Original Sin 2*, less than 5% of players used the multiplayer "Game Master" mode, and less than 4% of players fought each other online in the "Arena" mode. Both games have a large number of players, meaning the modes did not go unused, but they only contributed value for a fraction of the user base and may not have justified the development time and cost.

Lower user ratings for multiplayer games suggest the hurdle to developing satisfying multiplayer content is higher. Players not only need functioning multiplayer, they also need enough other players using the same online features. If a mode or multiplayer in general is not likely to support a large enough community, then it would be better left out of the game.

8.4.3 Limitations to the analysis

Further research into the value and utilization of multiplayer functionality in games is required to help project owners make better decisions. Currently, few numbers

are available regarding development costs for multiplayer projects. What numbers do exist are either anecdotal, or are given in a post-mortem fashion, which has two problems: post-mortems tend to have a success bias because they are done for games that survive to release, and post-mortems only cover the final numbers, not the initial projections or the amount of resources lost due to scope underestimation or change. Detailed research into the actual cost and schedule impact of multiplayer is required, particularly on the impact of making the decision in the early phases of development versus later phases.

Also, although a limited sample of multiplayer usage rates based on *Steam* achievements was included, a comprehensive survey of multiplayer usage rates is needed to provide specific insight into multiplayer utility value, particularly the multiplayer value to players from different implementation varieties.

8.5 Implications for Video Game Functional Scope Decisions

Developers not only need to make scope decisions based on the potential value that scope will provide to their players, developers need to make those decisions early in the process and stick to them to avoid the costs that come from re-scoping. In particular, functional scope decisions impact the complexity of a software project making them more difficult to change partway through development compared to content scope decisions. Through this research, we were able to explore the implications of the functional scope decision to include multiplayer and answer our initial questions:

- Does the inclusion of multiplayer have a positive impact on sales?

Given that the highest selling games tend to have multiplayer, and that the average number of owners with both single and multiplayer features was higher than that of games with only single-player functionality, there seems to be a sales benefit to including multiplayer.

- Does the inclusion of multiplayer impact user ratings and professional critic ratings?

The inclusion of multiplayer has no impact on professional critics' ratings, and

actually has a negative impact on user ratings, indicating there is a disadvantage to including multiplayer, possibly because it opens the game up to higher expectations or because the experience is impacted by other players.

- Are the multiplayer features of games that focus on single-player content used by the majority of players?

Relatively low utilization of multiplayer features in games with a single-player focus seems to indicate that forcing a multiplayer feature into a game will not provide additional value to most users.

- Is the inclusion of a multiplayer feature worth the development effort?

Multiplayer-only games have the potential to become the biggest hits, and do not appear to suffer from the lack of single-player features. However, players have high expectations for multiplayer; if these expectations cannot be met, results can suffer. Many of these expectations are beyond the control of the developer: online community population, network latency, and social issues such as cheating, community norm violations, and harassment can all negatively impact perceptions of a multiplayer experience.

Traditionally, there has been a pressure to implement multiplayer features because they add utility for players, discourage piracy, and prevent used sales, but in a digital distribution environment, the latter two reasons no longer apply. The results of this research demonstrated that there is value to including multiplayer functionality; however, that value may not be enough to justify the additional costs, time, and risks added to development or the diluting of the single-player experience. Based on the data, unless a developer is confident that their multiplayer mode will be capable of maintaining a strong audience as well as contribute significantly and positively to the game experience, it would be better to avoid it if the costs and risks of implementing it are high.

8.6 Utilizing KDD with External Data to Verify Decisions

Regarding the Value of Product Functional Scope in the Video Game Industry

The research presented in this chapter employed KDD techniques to quantify multiplayer function consumption trends in video games to provide the second part of the answer to the question:

- How do the product scope decisions made in video game project management reflect what provides value to consumers?

Just as with product content scope, given the limited budgetary resources for developing a video game project, organizations must decide what product features included in the functional scope will strike the optimum balance between functionality and quality for their target consumers if they want to make the best use of those resources. The benefits of the knowledge gained through employing a KDD technique such as the one presented to decision-makers deciding whether to implement potentially expensive functionality like “multiplayer” is the ability to rationally predict the value such a feature will provide to consumers. Understanding when a feature is justified allows product owners and project managers to weigh the costs of developing that feature against the expected benefits of providing it to consumers. (Figure 8-1)

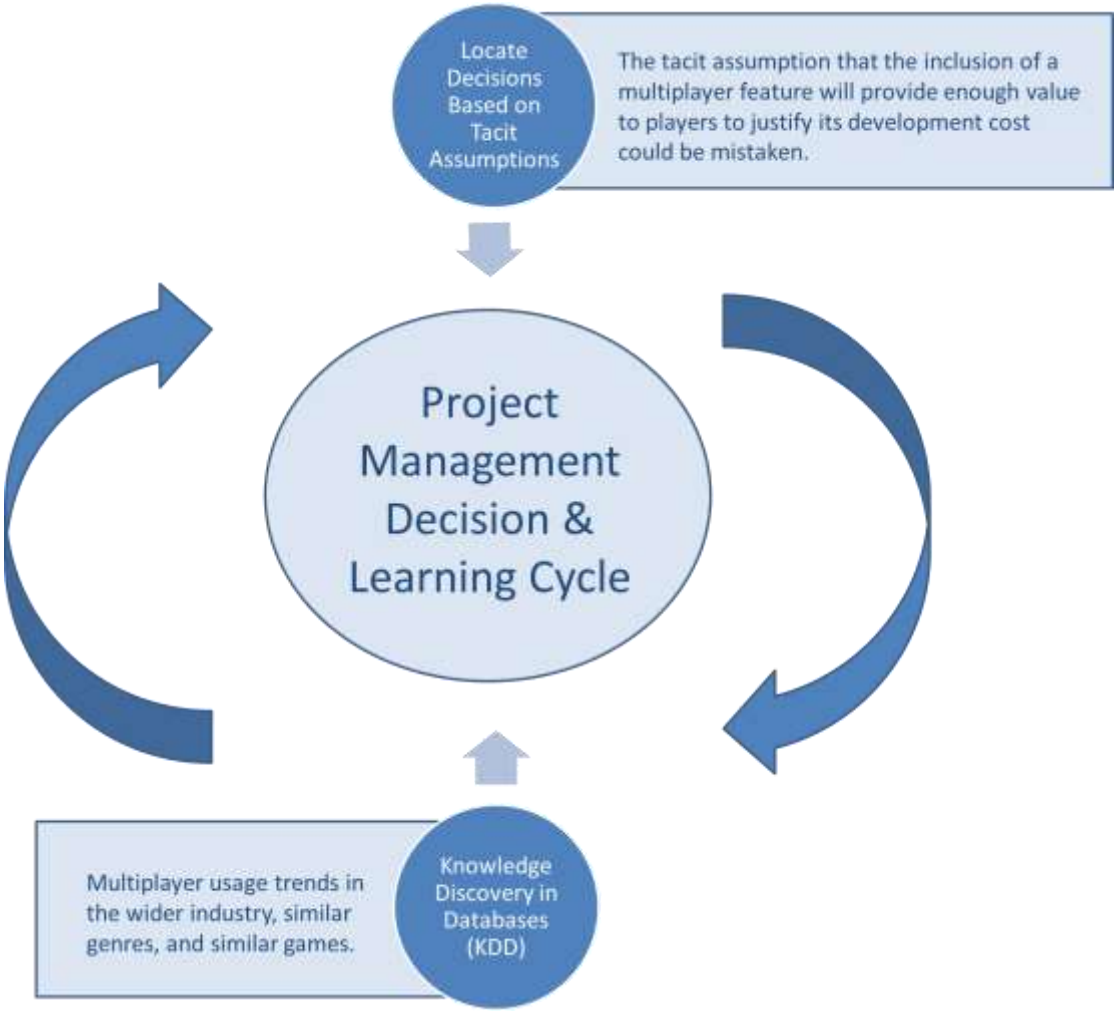

Figure 8-1. Incorporating publicly available Steam achievement data to validate or position assumptions regarding whether players value the inclusion of multiplayer functionality.

9. Summary

In Chapter 2, I explored the issues faced by video game business organizations such as developers and publishers to demonstrate the need for improved decision-making processes. Then in Chapter 3, I presented prior research into the cultural and creative industries, project and software management, knowledge management and knowledge discovery in databases (KDD), and consumer value to introduce important concepts for understanding the background against which this research was conducted. In Chapter 4, I noted the limitations of tacit knowledge and proposed a new process for falsifying or validating tacit knowledge that has accumulated within decision makers in the video game industry with potential application to other cultural and creative industries. This approach was employed in the case examples described in Chapters 5, 6, 7, and 8 covering a range of business management decisions in the video game industry. In Chapter 5, I discovered that video game publishers are growing more conservative in their innovation portfolio strategies, focusing more on intellectual property exploitation than exploration strategies. The research also explained why, in a market where innovation provides opportunities for future value generation, relying on this strategy could be dangerous. In Chapter 6, I found that, while gender diversity is improving, there are still few women involved in video game development, particularly in more powerful positions. The research presented one limitation to the diversity of tacit knowledge holders making decisions in the video game industry and how that limitation could impact opportunities to innovate and provide value for a more heterogeneous consumer base. In Chapters 7 and 8, I analyzed video game project content and functional scope management decisions and whether those decisions were providing the value to justify the added complexity and costs involved in their implementation. Given the discoveries on low content usage rates and situations where multiplayer modes added limited value, video game developers could be overestimating how much game their players desire, resulting in unnecessary complexity and resources being devoted to the wrong areas.

In Chapter 9, the final chapter, I summarize my findings and how they connect to the wider body of knowledge science and knowledge management research and present the practical implications of this research to video game and other creative industry organizations for improving their business decision processes. I also present the limitations to this research that lead to areas worth exploring in future research.

9.1 Findings

Chapters 5, 6, 7, and 8 were concerned with answering the following three questions put forth at the beginning of this dissertation:

- What is the state of intellectual property exploitation and exploration strategies in innovation and business management practices within leading video game organizations and how are those strategies changing?
- What role do women play in making creative decisions within video game development organizations and how does this compare to video game consumer demographics?
- How do the product scope decisions made in video game project management reflect what provides value to consumers?

The investigation into hit "AAA" video game development conducted in Chapter 5 answered the first question by using a KDD technique to verify that video game developers are growing more conservative, favoring intellectual property exploitation strategies over exploration strategies. This confirmed what Tschang (2007) argued through earlier qualitative research into video game development that the increasing complexity in developing hit games has led to decision-makers favoring proven game franchises and genres. The need to provide culture consumers with innovative new content entails risks, and creative industries are forced to rely on "hits" to make up for the many losses that a strategy focusing on innovation entails. (Hesmondhalgh, 2008, Jeffcutt and Pratt, 2002) Although publishers are increasingly relying on this strategy, the research also quantified the long-term risks involved by showing that the potential for value growth declines over the course of relying on a "proven" intellectual property (IP) franchise.

Chapter 6 answered the second question by focusing on the diversity of men and women in video game development positions, with a particular focus on positions with creative voice or organizational power. Williams et al. (2009) earlier showed that women were underrepresented as characters in video games and argued that the games being developed did not serve the larger market and could reflect the demographics of the

developers. My research employed a KDD technique to demonstrate how, although women in general are underrepresented in video game development work, they are further underrepresented in positions that provide the power to make decisions. This has implications for video game organizations who wish to serve their diverse audience, because the creators deciding the content that goes into games are largely men.

The third question was answered in Chapters 7 and 8, which used KDD techniques to analyze the results of content and functional scope decisions by video game project owners. Games are built for entertainment, and many game project managers as well as marketers assume that "more is better," but creating more game content requires more resources, and, after a certain point, additional content results in diminishing returns as the number of people who interact with the content falls. (Bauckhage et al., 2012, Sifa et al., 2014) The research found that much of the content developed for video games is not played and that the implementation of a multiplayer mode is not always appropriate given how costly and complex it can be to develop.

The research explored in Chapters 5, 6, 7, and 8 demonstrated ways that KDD techniques can be employed against data from the wider video game industry to falsify or validate tacit management assumptions, and the answers to these three research questions provided case examples for the process of incorporating data from outside a video game firm's boundaries to falsify or verify the tacit assumptions behind decisions being made and demonstrated how the process proposed in Chapter 4 can serve as an answer to the following question:

- How can an economic perspective that views decision optimization in terms of making the best use of limited organizational resources allow for the use of data from the wider industry to question assumptions and improve video game business management decision processes?

The process proposed in Chapter 4 was a modified double-loop learning cycle (Figure 9-1) that incorporates locating decisions based on falsifiable tacit assumptions and employing KDD techniques on data external to the organization to falsify or verify those assumptions.

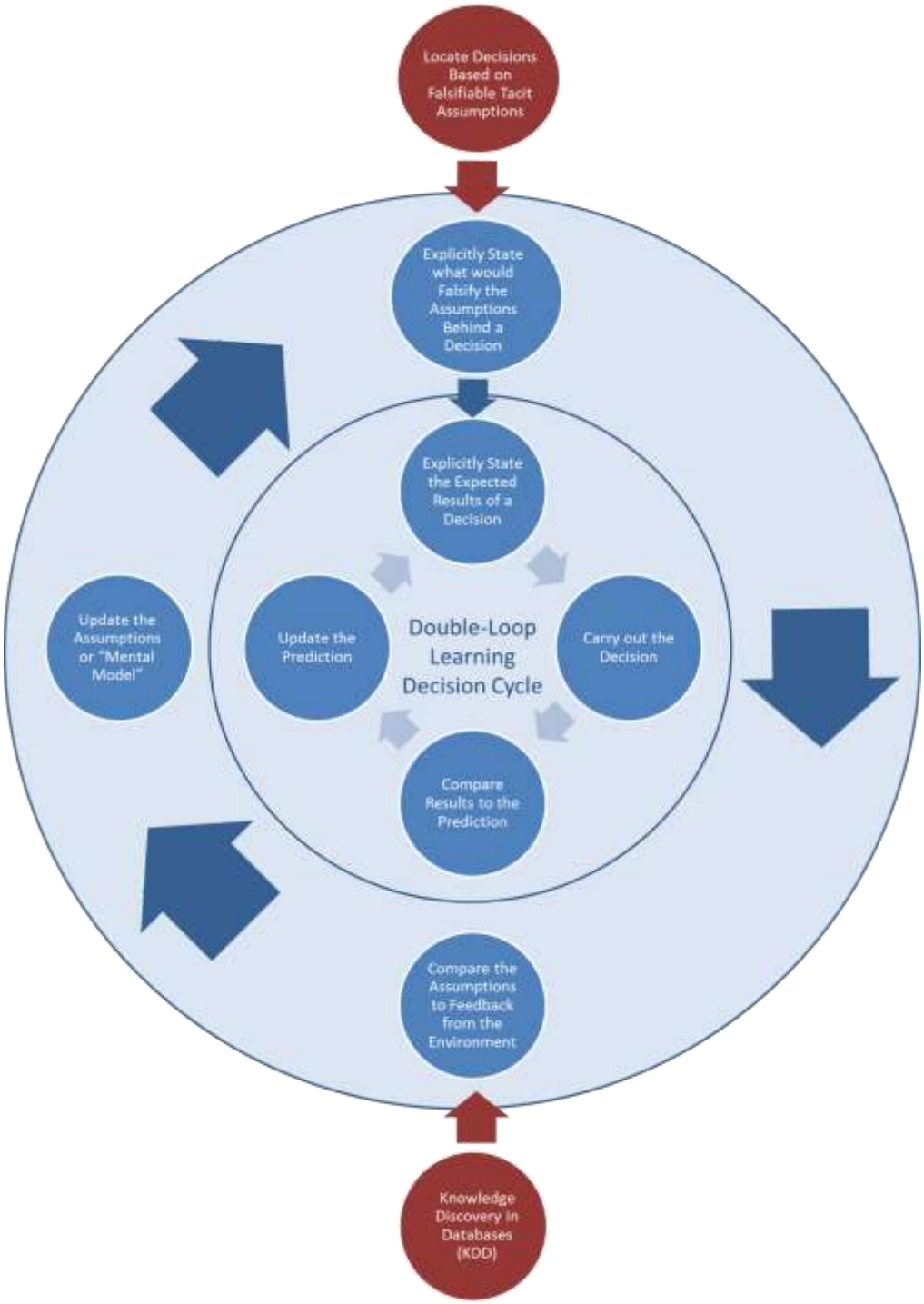

Figure 9-1. A learning and decision cycle that addresses the shortfalls of a standard double-loop learning cycle when employed in the creative industries that includes location of decisions based on falsifiable tacit assumptions and the usage of knowledge discovery in database (KDD) techniques to falsify or verify those assumptions using data from the wider industry.

9.2 Academic Contribution

"Cultural" or "creative" industries differ from other industries in that the most important "ingredients" of the product that provide value to consumers are intangible, or "symbolic." (Bilton, 2017) The creative industries are a valuable area for knowledge science research because they are reliant on the experience-based tacit knowledge of their employees to generate value. In the creative industries, every project is an experiment testing an ever-changing market. (Lorenzen and Frederiksen, 2005) With the video game industry, which served as the focus of this research, the rapid pace of change soon renders prior knowledge irrelevant. (Parkin, 2018) For this reason, creative industries, like the video game industry, can provide insight into how concepts like tacit knowledge can influence decision making in the context of a rapidly changing market "reality", and provide a resource for discovering ways tacit knowledge and assumptions can be corrected or verified by employing KDD approaches like data mining.

Tacit knowledge is important for the cultural and creative industries where creativity is the source of value; however, this knowledge is limited by the experience of the holder and the holder's intuition regarding those experiences. Leonard and Sensiper (1998) warned that, because of this limitation, tacit knowing may not be valuable or accurate. Knowledge reflects the judgments, values, and beliefs of the holder. (Davenport and Prusak, 2000, p. 10) If these beliefs are mistaken, they can be difficult to correct because existing knowledge can become a barrier to learning. Warnings from prior research about "competence traps", "structural inertia", "the curse of knowledge", "core rigidities", "false knowing", "complacency", "defensive routines", and the "tyranny of the will" all point to the dangers of relying too heavily on unverifiable tacit knowledge. (Argyris, 1999, Camerer et al., 1989, Carlile, 2004, Hannan and Freeman, 1984, Leonard-Barton, 1995, Leonard, 2011, Levinthal and March, 1993, Levitt and March, 1988)

Popper (1979, p. 167) stressed the importance of controlling fallible intuition with rational criticism, because "control through criticism is the rational aspect of the growth of knowledge." Without a systematic learning process that explicitly states assumptions that are then verified, the results of a decision can be reinterpreted to seem correct. (Levitt and March, 1988) This research contributed to knowledge management research in the creative industries by introducing a systematic learning process that adapts the traditional "double-loop learning" model (Argyris, 1977) to work in creative industries, where tacitly held assumptions drive much of the value-creation process. It identifies decisions that could rely on mistaken tacit assumptions and

incorporates data from the wider industry into the validation process. It relies on Popper's (1963) use of falsification rather than confirmation to avoid the reinterpretation problem, which is essentially a problem of induction – interpreting results in a way that supports a theory. This problem needs to be addressed in a learning cycle within the context of a cultural industry like video game development because "value is subjective" and decisions are made based on implicit values rather than explicit strategies, which would be open to debate and verification. (Bilton, 2007) Also, the rapidly changing market leads to turbulence that makes learning difficult (March, 1991), as tacit knowledge that may have had value in past experiences is quickly outdated. In the creative industries where consumer values change, this tacit knowledge is an "amorphous resource" that can its value. (Lampel et al., 2006) One of the primary risks of relying entirely on tacit knowledge is that the "ambiguity" that surrounds it makes it difficult to challenge and change even if it is mistaken. (Levitt and March, 1988) Without falsification, the lessons learned from interactions in the marketplace could be less influenced by the actual realities of the marketplace but more by the interpretive framework applied to those events. (Levitt and March, 1988)

This research provides examples of the knowledge science concepts of tacit knowledge, organizational learning, and KDD applied in practice with the validation of decision-making assumptions using the video game industry case. This research also contributes to managerial economics (Dean, 1951) and extends the economic approach to decision-making suggested by Boehm (1984) for software engineering by providing an example of how "the products (and more importantly the methodology) of economic science" can be used "to make better decisions" (Hill, 1989, p. 1) in the creative industries with the case of the video game industry when applied in the context of business. This research does this by using a managerial economics perspective to judge the merits of tacit assumptions by the value they generate for the business given decisions regarding the best use of limited resources. In this way, creative decisions are quantifiable and can be falsified or validated in a rational manner.

Each example of the proposed process quantified a different management area in video game development: strategic innovation management, human resource or "talent management", and project product scope management, in order to show how data and KDD techniques can be used to confront structural inertia and improve decision processes throughout video game organizations and other cultural industry organizations, which have relied on the tacit knowledge their employees have accrued through experience on a limited set of projects.

First, the quantification of IP exploration and exploitation trends in Chapter 5

served to confirm the prior findings by Tschang (2007) in qualitative research that the video game industry is growing more conservative as a method for reducing the uncertainty and hedging against the growing risks of development. It also extends earlier quantitative research by Ikuine (2006), who focused on the Japanese video game market in the 1980s and 1990s, by examining the game catalogs of the top eight third-party publishers of console and PC games by revenue globally from 1980 through 2018.

Next, the quantification in Chapter 6 of women represented in positions of power or with creative voice within video game development organizations confirmed the suspicions of Williams et al. (2009) that the content in video games reflects the demographics of the developers, and discovered the same inequalities found by Smith et al. (2018) for positions with creative power in the movie industry also exist in the video game industry. Chapter 6 also introduced a novel visualization technique for discovering trends basic statistical analysis could miss in staff list gender representation. This technique could be applied outside of the video game industry to any industry where its employees are credited in a staff list scheme.

The quantification of product content scope usage patterns in PC video games in Chapter 7 extends existing research into usage patterns focused on a subset of games by Bauckhage et al. (2012), Sifa et al. (2014), and Weber et al. (2011a) through a novel approach that relies on KDD techniques and detecting video game "completion rates" by examining achievement tags in a large body of video games. The quantification of the value of multiplayer functionality in Chapter 8 also presents how the same achievement analysis technique can be applied to extend the findings by Hullet et al. (2011) that multiplayer functionality often goes unused.

9.3 Practical Implications

Until now, there has been little research into decision-making within business management in the video game industry. The video game industry has grown to a $150 billion business, with project development budgets beginning to exceed $100 million. (Bleeker, 2013, Wijman, 2019) The video game industry is growing, but the size of project budgets and teams is growing as well, making the risks of failure higher. A decision based on limited tacit knowledge that could be mistaken or outdated could lead to the business failure of a video game developer or publisher. Although the industry, as a creative industry, relies on the tacit knowledge of its workers to generate value, the existence of long-running businesses alongside many entries and exits indicates that some knowledge is more valuable to the survivability of organizations in the context of

their competition. Improved decision-making is a requirement for organizational survival in a rapidly changing environment, where tacit knowledge can grow outdated. The need to judge the business value of tacitly held assumptions against competitors in the wider industry means that the video game and other creative industries can benefit from the application of knowledge science concepts such as organizational learning and KDD.

There is evidence to suggest that an investment in management can help improve the survival rate of video game companies. (Cabras et al., 2017) However, Lampel et al. (2000) pointed out that management in the creative industries has been neglected by research. This lack of research is due in part to the consideration that management has not traditionally been considered central to business success in the creative industries. (Jeffcutt and Pratt, 2002) As it is, many creative industry organizations rely on unquestioned experience-based tacit knowledge to make management decisions; however, left unquestioned, this knowledge can "reinforce unquestioned habits of thought" and, in the extreme, lead to a "dictatorial" approach to management. (Bilton, 2007, p. 103) Jasper (2010) warned that this unwarranted overconfidence is a source of "creativity's dark side".

The data-informed learning process proposed in this research is in line with Pfeffer and Sutton (2006), who recommended an "evidence-based management" approach, where claims should be backed by evidence, such as data or observations from experimentation. Using data to correct mistaken tacit assumptions and inform the decision process is critical to improving a business. Businesses must create processes for capturing data from the market and utilize it within their knowledge management structures to keep their view of the market realities up-to-date. Only by doing this can they ensure they are investing resources in areas that genuinely create value for their consumers.

The value of tacit knowledge in the video game industry has traditionally been difficult to question in a rational process because its products, like that of other cultural industries, hold mostly symbolic value; however, focusing on the business value of this tacitly held knowledge allows for the employment of a managerial economics perspective, with its focus on using limited resources to maximize business value, which allows the products and methodology of economics to be applied to optimize decision-making. For a video game organization, or other profit-driven creative industry organization, to become a learning organization and thus competitive in a rapidly changing market, it must continue to validate the business value of tacitly held assumptions used in managerial decision-making. Only when the decision-making

process is modified to allow the questioning and validation of tacit assumptions can the knowledge behind those assumptions be updated to reflect underlying business realities.

This research addressed the need for improving the organizational learning and knowledge management processes in profit-driven creative industries like the video game industry. In particular, this research employed KDD techniques on data external to any one organization to be used in questioning tacitly held assumptions.

Chapter 4 introduced a process that extends a traditional double-loop learning cycle in two ways that address the flaws that would make it difficult to employ in a creative industry. First, it relies on observation from a member, preferably external to the project team or organization, to "locate" decisions made based on falsifiable tacit assumptions of the decision-maker; second, it stresses the importance of falsifying or validating those assumptions against data sources external to an organization – industry-wide data sources if they are available. Creative industry organizations, such as video game developers, seek an "optimum level of differentiation", and, because tacit knowledge drives so much of the value in its products, a "data-driven" approach would be inappropriate as it would drive organizations to imitate when they need to innovate. The proposed process recognizes that tacit knowledge is the source of most of the value in the symbolic products that are produced in a creative industry like video game development and suggests a "data-informed" – where data is used to falsify or validate tacit assumptions – rather than a "data-driven" approach – where data is used to make the decisions.

This research applied the proposed process to four example cases that quantified the results of decisions in strategic innovation management, human resource or "talent management", and project product scope management in video game development organizations to show how existing tacit assumptions might not reflect video game development market realities. The process was employed to discover strategic innovation management trends in top third-party video game publishers in Chapter 5, the presence of women in positions with creative voice in the development process in Chapter 6, the amount of content that is "used" by players of PC video games in Chapter 7, and the value of including a "multiplayer" function in PC video games in Chapter 8. These discoveries in themselves are valuable to video game development organizations, but more importantly, the same KDD methodology can be applied to falsifying or validating tacitly held assumptions behind other management decisions.

9.4 Limitations and Areas for Future Research

Although examples were provided for how KDD and applying a managerial economic perspective can be employed in strategic management, human resource management, and project management within the video game industry, there are other decisions even within these three areas of management that can be researched to provide methods for quantifying the results of tacit assumptions in decision-making. Within innovation management, the research could be extended to mid-tier and independent video game development organizations to discover how small to mid-sized companies are adjusting their exploration-exploitation strategies. The diversity of decision makers explored by this research was limited to cisgender male and female diversity within video game organizations, but non-cisgender diversity and other sources of demographic diversity as well as sources of cognitive diversity should be explored to discover who is represented in the decision-making process and whether those decision makers represent the players for who they are creating games. Finally, further research into ways data mining techniques can validate project management decision assumptions can be conducted to include content and functional scope decisions made for video games on platforms outside of *Valve Corporation*'s *Steam* platform. Also, multiplayer is only one example of functional scope, but other forms of functional scope, such as the complexity of game systems, could be examined to discover whether the additional costs and time required to develop that complexity are worth the effort involved. Scope is also only one facet of project management, but KDD techniques for validating the value of other project management decisions, such as budget or quality control could also be explored.

Another important avenue for future research is to conduct case study and action research on decision-making processes within the video game industry to gain a richer understanding of how tacit knowledge and topics like corporate politics can influence or impede a rational decision-making process. This line of research is critical to gaining an understanding for how an improved learning cycle can be implemented in a range of organizations that may be more or less receptive to change.

Finally, the focus of this research was on only one creative industry, the videogame industry; however, other creative industries, which also rely on the experience-based tacit knowledge of their employees to generate value, are likely to have unique challenges that could benefit from the proposed approach. Research using the techniques in this research to validate tacit assumptions through data in other creative industries, or industries where customer needs are vague and change rapidly,

could help improve decision-making in a wider range of organizations.

Publications

Full Papers in Refereed Academic Journals (International)

Bailey, E., & Miyata, K. (2019). ”Improving video game project scope decisions with data: An analysis of achievements and game completion rates.” *Entertainment computing*. Vol. 31. p. 100299, doi: 10.1016/j.entcom.2019.100299

Bailey, E., Miyata, K., & Yoshida, T. (2019). “Gender composition of teams and studios in game development.” *Games and culture.* doi: 10.1177/1555412019868381

Full Papers under Consideration for Publishing

Bailey, E., Miyata, K. (in review). “Exploration and exploitation in video game development: An analysis of the shift in innovation trends in third-party console game publishers.”

Academic Conference Oral Presentations & Proceedings (International)

Bailey, E., & Miyata, K. (2018). “Estimating the value of multiplayer modes in video games: An analysis of sales, ratings, and utilization rates.” 10th International Joint Conference on Knowledge Discovery, Knowledge Engineering and Knowledge Management (IC3K) / Knowledge Discovery and Information Retrieval (KDIR) 2018. (oral presentation, proceedings paper)

Bailey, E., & Ito, Y. (2017). “Live streaming changes video game testing: Observing contextual player behavior over video streaming services.” Annual Meeting of the Society for Social Studies of Science (4S). (oral presentation)

Bailey, E., & Ito, Y. (2017). “Livestreaming for user testing: Context-rich observation of game player behavior.” International Conference on Management, Science and Engineering (ICMSE) 2017. (oral presentation, proceedings paper)

Academic Conference Poster Sessions & Proceedings (International)

Bailey, E., & Miyata, K. (2017). “Analyzing video game completion achievements: Implications for game project scope,” IFIP International Conference on Entertainment Computing (ICEC) 2017. (poster presentation, proceedings paper)

Other Conference Presentations

Sato, N., & Bailey, E. (2017).「GRAVITY DAZE 2」ゲームシナリオ制作：または私は如何にして心配するのを止めて制限を愛するようになったか。Computer Entertainment Developers Conference (CEDEC) 2017. (oral presentation)

References

2018. McCracken et al. v Riot Games. classaction.org: Super Court of the State of California, County of Los Angeles -- Central District.

Abernathy, W. J. 1978. *The Productivity Dilemma: Roadblock to Innovation in the Automobile Industry,* Baltimore, John Hopkins University Press.

Ackoff, R. L. 1999. *Re-creating the corporation: A design of organizations for the 21st century*, Oxford University Press.

Adler, P. S., Benner, M., Brunner, D. J., MacDuffie, J. P., Osono, E., Staats, B. R., Takeuchi, H., Tushman, M. & Winter, S. G. 2009. Perspectives on the productivity dilemma. *Journal of Operations Management,* 27(2), 99-113.

Alexander, L. 2009. *Riccitiello: Quality, Sales Correlation Takes Time to Show* [Online]. Gamasutra. Available: https://www.gamasutra.com/view/news/117281/Riccitiello_Quality_Sales_Correlation_Takes_Time_To_Show.php [Accessed March 21st, 2020].

Ali, M., Kulik, C. T. & Metz, I. The Impact of Gender Diversity on Performance in Services and Manufacturing Organizations. Academy of management proceedings, 2009. Academy of Management Briarcliff Manor, NY 10510, 1-6.

Andriopoulos, C. & Lewis, M. W. 2009. Exploitation-exploration tensions and organizational ambidexterity: Managing paradoxes of innovation. *Organization Science,* 20, 696-717.

Aoyama, Y. & Izushi, H. 2003. Hardware gimmick or cultural innovation? Technological, cultural, and social foundations of the Japanese video game industry. *Research policy,* 32(3), 423-444.

Argyris, C. 1977. Double Loop Learning in Organizations. *Harvard Business Review,* 55(5), 115-125.

Argyris, C. 1991. Teaching smart people how to learn. *Harvard Business Review,* 69(3), 99-109.

Argyris, C. 1999. *On Organizational Learning 2nd Edition*, Blackwell Publishing.

Argyris, C. 2000. *Flawed advice and the management trap: How managers can know when they're getting good advice and when they're not*, Oxford University Press.

Arkes, H. R. & Blumer, C. 1985. The psychology of sunk cost. *Organizational behavior and human decision processes,* 35(1), 124-140.

Armstrong, A. & Page, N. 2015. Creativity and constraint: Leadership and management in the UK creative industries. *Hertfordshire: Ashridge Business School.*

Ashcraft, C., McLain, B. & Eger, E. 2016. Women in tech: The facts 2016 update. National

Center for Women and Information Technology.

Backhouse, R. E. & Medema, S. G. 2009. Retrospectives: On the definition of economics. *Journal of economic perspectives,* 23**,** 221-33.

Bailey, E. N. & Ito, Y. Live streaming changes video game testing: Observing contextual player behavior over video streaming services. Annual Meeting of the Society for Social Studies of Science (4S), September 1st, 2017 2017a Boston.

Bailey, E. N. & Ito, Y. Livestreaming for User Testing Context-Rich Observation of Game Player Behavior. 2017 International Conference on Management Science and Engineering (ICMSE), August 25th, 2017 2017b Nomi, Ishikawa. IEEE, 228-237.

Bakker, G. 2010. The evolution of the British entertainment business: Film, music and videogames. *BIS Economics Paper,* No. 6.

Bakker, G. 2014. Sunk costs and the dynamics of creative industries. *In:* JONES, C., SAPSED, J. & LORENZEN, M. (eds.) *The Oxford Handbook of Creative Industries.* Oxford University Press.

Bauckhage, C., Kersting, K., Sifa, R., Thurau, C., Drachen, A. & Canossa, A. 2012. How players lose interest in playing a game: An empirical study based on distributions of total playing times. *2012 IEEE Conference on Computational Intelligence and Games (CIG)***,** 139-146.

Bazerman, M. H. 1984. The relevance of Kahneman and Tversky's concept of framing to organizational behavior. *Journal of Management,* 10**,** 333-343.

Bilton, C. 2007. *Management and creativity: From creative industries to creative management*, Blackwell Publishing.

Bilton, C. 2017. *The disappearing product: Marketing and markets in the creative industries*, Edward Elgar Publishing.

Bilton, C. & Leary, R. 2002. What can managers do for creativity? Brokering creativity in the creative industries. *International Journal of Cultural Policy,* 8(1)**,** 49-64.

Bird, A. 1994. Careers as repositories of knowledge: A new perspective on boundaryless careers. *Journal of Organizational Behavior,* 15**,** 325-344.

Blackman, D., Connelly, J. & Henderson, S. 2004. Does double loop learning create reliable knowledge? *The Learning Organization,* 11(1)**,** 11-27.

Bleeker, E. 2013. *Grand Theft Auto 5 sales hit $1 billion, will outsell entire global music industry* [Online]. Available: https://www.fool.com/investing/general/2013/09/28/gta-5-sales-hit-1-billion.aspx [Accessed February 28, 2017].

Blow, J. 2004. Game development: Harder than you think. *Queue,* 1(10)**,** 28.

Boehm, B. W. 1983. Seven basic principles of software engineering. *Journal of Systems and*

Software, 3(1), 3-24.

Boehm, B. W. 1984. Software engineering economics. *IEEE Transactions on Software Engineering,* 10(1), 4-21.

Boehm, B. W. & Papaccio, P. N. 1988. Understanding and controlling software costs. *IEEE Transactions on Software Engineering,* 14(10), 1462-1477.

Bonds, S., Briant, J., Clingman, D., Howie, H., Laramée, F. D., LoPiccolo, G., Luckey, A. & McShaffry, M. 2004. Quality of life in the game industry: Challenges and best practices. International Game Developers Association (IGDA).

Boor, M. 1990. Reliability of ratings of movies by professional movie critics. *Psychological Reports,* 67(1), 243-257.

Boor, M. 1992. Relationships among ratings of motion pictures by viewers and six professional movie critics. *Psychological Reports,* 70(3_suppl), 1011-1021.

Bourdieu, P. 1985. The market of symbolic goods. *Poetics,* 14, 13-44.

Brooks, F. P. J. 1975. *The mythical man month: Essays on software engineering.*, Addison-Wesley.

Brown, P., Haas, S., Marchessou, S. & Villepelet, C. 2018. Shatting the glass runway. McKinsey & Company.

business.com Editorial Staff. 2012. *Business Managament's 8 Branches* [Online]. business.com: business.com. Available: https://www.business.com/articles/8-branches-of-business-management/ [Accessed March 25th, 2020].

Cabras, I., Goumagias, N. D., Fernandes, K., Cowling, P., Li, F., Kudenko, D., Devlin, S. & Nucciarelli, A. 2017. Exploring survival rates of companies in the UK video-games industry: An empirical study. *Technological forecasting and social change,* 117, 305-314.

Calantone, R. J. & Cooper, R. G. 1979. A discriminant model for identifying scenarios of industrial new product failure. *Journal of the Academy of Marketing Science,* 7, 163-183.

Camerer, C., Loewenstein, G. & Weber, M. 1989. The curse of knowledge in economic settings: An experimental analysis. *Journal of political Economy,* 97, 1232-1254.

Canossa, A., Anders, D. & Sørensen, J. R. M. 2011. Arrrgghh!!! - Blending quantitative and qualitative methods to detect player frustration. *Proceedings of the 6th International Conference on the Foundations of Digital Games,* FDG '11, 61-68.

Carlile, P. R. 2004. Transferring, translating, and transforming: An integrative framework for managing knowledge across boundaries. *Organization science,* 15, 555-568.

Cattani, G. & Ferriani, S. 2008. A core/periphery perspective on individual creative

performance: Social networks and cinematic achievements in the Hollywood film industry. *Organization science,* 19**,** 824-844.

Caves, R. E. 2000. *Creative industries: Contracts between art and commerce*, Harvard University Press.

Charette, R. N. 2005. Why software fails. *IEEE Spectrum,* 42(9)**,** 42-49.

Choo, C. W. 2006. *The knowing organization: How organizations use information to construct meaning, create knowledge, and make decisions*, Oxford University Press.

Clarke, R. I., Lee, J. H. & Clark, N. 2017. Why video game genres fail: A classificatory analysis. *Games and Culture,* 12(5)**,** 445-465.

Cohen, W. M. & Levinthal, D. A. 1990. Absorptive capacity: A new perspective on learning and innovation. *Administrative science quarterly,* 35**,** 128-152.

Cohendet, P., Llerena, P. & Simon, L. 2014. The Routinization of Creativity. *Jahrbücher für Nationalökonomie und Statistik,* 234**,** 120-141.

Cohendet, P. & Simon, L. 2007. Playing across the playground: Paradoxes of knowledge creation in the videogame firm. *Journal of Organizational Behavior,* 28(5)**,** 587-605.

Cohendet, P. S. S., Laurent O. 2017. Always playable: Recombining routines for creative efficiency at Ubisoft Montreal's video game studio. *Organization Science,* 27(3)**,** 614-632.

Coman, A. & Ronen, B. 2010. Icarus' predicament: Managing the pathologies of overspecification and overdesign. *International Journal of Project Management,* 28(3)**,** 237-244.

Conference, G. D. 2019. *GDC Diversity & Inclusion* [Online]. Game Developers Conference. Available: https://www.gdconf.com/diversity [Accessed February 2nd, 2018].

Curtis, B., Krasner, H. & Iscoe, N. 1988. A field study of the software design process for large systems. *Communications of the ACM,* 31(11)**,** 1268-1287.

D'Anastasio, C. 2018. *Inside the culture of sexism at Riot Games* [Online]. Kotaku.com. Available: https://kotaku.com/inside-the-culture-of-sexism-at-riot-games-1828165483 [Accessed January 4th, 2019].

Davenport, T. H. 2006. Competing on analytics. *Harvard Business Review,* 84(1)**,** 98.

Davenport, T. H., Harris, J. G., De Long, D. W. & Jacobson, A. L. 2001. Data to knowledge results: Building an analytic capability. *California Management Review,* 43(2)**,** 117-138.

Davenport, T. H. & Prusak, L. 2000. *Working Knowledge: How Organizations Manage What They Know*, Harvard Business Press.

De Vany, A. & Walls, W. D. 1999. Uncertainty in the movie industry: Does star power reduce

the terror of the box office? *Journal of cultural economics,* 23**,** 285-318.

Dean, J. 1951. *Managerial economics,* New York, Prentice Hall.

DeFillippi, R. 2009. Dilemmas of project-based media work: Contexts and choices. *Journal of Media Business Studies,* 6**,** 5-30.

DeFillippi, R., Grabher, G. & Jones, C. 2007. Introduction to paradoxes of creativity: Managerial and organizational challenges in the cultural economy. *Journal of Organizational Behavior,* 28(5)**,** 511-521.

DeFillippi, R. J. & Arthur, M. B. 1994. The boundaryless career: A competency - based perspective. *Journal of organizational behavior,* 15**,** 307-324.

Della Rocca, J. 2006. *Friction costs: How immature production practices and poor quality of life are bankrupting the game industry* [Online]. Available: http://www.escapistmagazine.com/articles/view/video-games/issues/issue_40/243-Friction-Costs [Accessed December 12, 2016].

DeMarco, T. & Lister, T. 1987. *Peopleware: Productive people and teams,* New York, NY, Dorset House.

DeMarco, T. & Lister, T. 2003. *Waltzing with bears: Managing risk on software projects,* New York, NY, Dorset House.

Denrell, J. & March, J. G. 2001. Adaptation as information restriction: The hot stove effect. *Organization Science,* 12(5)**,** 523-538.

Deuze, M. 2016. Managing media workers. *Managing Media Firms and Industries.* Springer.

Deuze, M., Martin, C. B. & Allen, C. 2007. The professional identity of gameworkers. *Convergence,* 13**,** 335-353.

Devillard, S., Sancier-Sultan, S., de Zelicourt, A. & Kossoff, C. 2016. Women Matter 2016: Reinventing the workplace to unlock the potential of gender diversity. McKinsey & Company.

Dick, M., Wellnitz, O. & Wolf, L. Analysis of factors affecting players' performance and perception in multiplayer games. Proceedings of 4th ACM SIGCOMM workshop on Network and system support for games, 2005. ACM, 1-7.

Dickey, M. D. 2006. Girl gamers: The controversy of girl games and the relevance of female - oriented game design for instructional design. *British journal of educational technology,* 37**,** 785-793.

DiMaggio, P. J. & Powell, W. W. 1983. The iron cage revisited: Institutional isomorphism and collective rationality in organizational fields. *American sociological review***,** 147-160.

Draper, J. 2014. Theorizing creative agency through 'discerned savvy': A tool for the critical study of media industries. *Media, Culture & Society,* 36**,** 1118-1133.

Drucker, P. F. 1969. *The age of discontinuity: Guidelines to our changing society,* New

Brunswick, Transaction Publishers.

Drucker, P. F. 1974. *Management: Tasks, responsibilities, practices,* New York, NY, Harper & Row.

Drucker, P. F. 1993. *Management: Tasks, Responsibilities, Practices,* New York, Harper Business.

Ebert, C. 2007. The impacts of software product management. *Journal of Systems and Software,* 80(6), 850-861.

Edmonson, A. C. 2012. *Teaming: How Organizations Learn, Innovate, and Compete in the Knowledge Economy*, John Wiley & Sons.

Engström, H., Marklund, B. B., Backlund, P. & Toftedahl, M. 2018. Game development from a software and creative product perspective: A quantitative literature review approach. *Entertainment Computing,* 27, 10-22.

Ensher, E. A., Grant - Vallone, E. J. & Donaldson, S. I. 2001. Effects of perceived discrimination on job satisfaction, organizational commitment, organizational citizenship behavior, and grievances. *Human resource development quarterly,* 12, 53-72.

Entertainment Software Association 2019. 2019 Essential Facts About the Computer and Video Game Industry. Entertainment Software Association.

Equity by Design Committee. 2016. *EQxD Metrics: Key Findings from the 2016 Equity in Architecture Survey* [Online]. Equity by Design (EQxD): American Institute of Architects (AIA). Available: http://eqxdesign.com/blog/2017/2/14/eqxd-metrics-key-findings-from-the-2016-equity-in-architecture-survey [Accessed October 13th, 2019].

Ernkvist, M. 2008. Down many times, but still playing the game: Creative destruction and industry crashes in the early video game industry 1971-1986.

Everett, G. D. & McLeod, R. J. 2007. *Software testing: Testing across the entire software development life cycle*, John Wiley & Sons.

Fahey, L. & Prusak, L. 1998. The eleven deadliest sins of knowledge management. *California Management Review,* 40(3), 265-276.

Fayyad, U., Haussler, D. & Stolorz, P. 1996a. Mining scientific data. *Communications of the ACM,* 39(11), 51-57.

Fayyad, U., Piatetsky-Shapiro, G. & Smyth, P. 1996b. From data mining to knowledge discovery in databases. *AI Magazine,* 17(3), 37-54.

Fink, L., Yogev, N. & Even, A. 2017. Business intelligence and organizational learning: An empirical investigation of value creation processes. *Information & Management,* 54(1), 38-56.

Flood, K. 2003. *Game unified process* [Online]. Available: https://www.gamedev.net/resources/_/technical/general-programming/game-unified-process-r1940 [Accessed October 25, 2016].

Florida, R. 2002. *The rise of the creative class and how it's transforming work, leisure, community and everyday life*, Basic Books.

Frank, R. H. C., Philip J. 1995. *The winner-take-all society*, Free Press.

Gamasutra. 2014. *Gamasutra Salary Survey 2014* [Online]. Gamasutra. Available: https://www.gamasutra.com/salarysurvey2014.pdf [Accessed].

Garvin, D. A. 1993. Building a learning organization. *Harvard Business Review,* 71(4), 78-91.

Gilbert, B. 2012. *Obsidian missed Fallout: New Vegas Metacritic bonus by one point* [Online]. engadget. Available: https://www.engadget.com/2012/03/15/obsidian-missed-fallout-new-vegas-metacritic-bonus-by-one-point/ [Accessed January 4th, 2019].

Gough, C. 2019. *Distribution of computer and video gamers in the United States from 2006 to 2019, by gender* [Online]. Statista: Statista. Available: https://www.statista.com/statistics/232383/gender-split-of-us-computer-and-video-gamers/ [Accessed March 28th, 2020].

Gourville, J. & Soman, D. 2002. Pricing and the psychology of consumption. *Harvard Business Review,* 80(9), 90-96.

Gov.uk 2017. Rockstar North Limited Gender pay gap report. Gov.uk.

Graves, L. M. & Powell, G. N. 1995. The Effect of Sex Similarity on Recruiters' Evaluations of Actual Applicants: A Test of the Similarity-Attraction Paradigm. *Personnel Psychology,* 48, 85-98.

Greenwood-Ericksen, A., Poorman, S. R. & Papp, R. 2013. On the validity of Metacritic in assessing game value. *Eludamos - Journal for Computer Game Culture,* 7(1), 101-127.

Gregory, D. 2008. *Building a mindset for rapid iteration* [Online]. Available: http://www.gamasutra.com/view/feature/132046/building_a_mindset_for_rapid_.php [Accessed October 28, 2016].

Hannan, M. T. & Freeman, J. 1984. Structural inertia and organizational change. *American Sociological Review*, 149-164.

Havens, T. 2007. Universal childhood: The global trade in children's television and changing ideals of childhood. *Global Media Journal,* 6.

Heinen, J. S. & O'Neill, C. 2004. Managing talent to maximize performance. *Employment Relations Today,* 31, 67.

Herriot, S. R. L., Daniel; March, James G. 1985. Learning from experience in organizations. *The American Economic Review,* 75(2), 298-302.

Hesmondhalgh, D. & Pratt, A. C. 2005. Cultural industries and cultural policy. *International journal of cultural policy,* 11, 1-13.

Hesmondhalgh, D. J. 2008. Cultural and creative industries. *In:* BENNETT, T. & FROW, J. (eds.) *The SAGE Handbook of Cultural Analysis.* Sage Publications.

Hill, S. 1989. *Managerial economics: The analysis of business decisions*, Macmillan International Higher Education.

Hirsch, P. M. 1972. Processing fads and fashions: An organization-set analysis of cultural industry system. *American Journal of Sociology,* 77(4), 639-659.

Hotho, S. & Champion, K. 2010. We are always after that balance: Managing innovation in the new digital media industries. *Journal of technology management & innovation,* 5(3), 36-50.

Hullet, K., Nagappan, N., Schuh, E. & Hopson, J. 2011. Data analytics for game development. *Proceedings of the 33rd International Conference on Software Engineering, 2011,* ICSE '11, 940-943.

Hullet, K., Nagappan, N., Schuh, E. & Hopson, J. 2012. Empirical analysis of user data in game software development. *Proceedings of the ACM-IEEE International Symposium on Empirical Software Engineering and Measurement,* ESEM '12, 89-98.

Humphrey, W. S. 1988. Characterizing the software process: A maturity framework. *IEEE Software,* 5(2), 73-79.

IGN. 2009. *Top 100 Game Creators* [Online]. IGN. Available: https://www.ign.com/lists/top-100-game-creators [Accessed January 13th, 2019].

Ikuine, F. 2006. *Gemu sofuto no inobeeshon pataan: Kaihatsu seisansei no direnma [Innovation patterns in the video game software industry: The development productivity dilemma].* Doctoral dissertation, University of Tokyo.

Irwin, M. J. 2008. *Cooking up a blockbuster game* [Online]. Available: http://www.forbes.com/2008/11/21/games-eedar-developers-tech-ebiz-cx_mji_1121eedar.html [Accessed August 25, 2016].

Janis, I. L. 1972. *Victims of groupthink: A psychological study of foreign-policy decisions and fiascoes,* Oxford, Houghton Mifflin.

Jasper, J. M. 2010. The innovation dilemma: Some risks of creativity in strategic agency. *In:* CROPLEY, D. H., CROPLEY, A. J., KAUFMAN, J. C. & RUNCO, M. A. (eds.) *The dark side of creativity.* Cambridge University Press.

Jayne, M. E. & Dipboye, R. L. 2004. Leveraging diversity to improve business performance:

Research findings and recommendations for organizations. *Human Resource Management: Published in Cooperation with the School of Business Administration, The University of Michigan and in alliance with the Society of Human Resources Management,* 43**,** 409-424.

Jeffcutt, P. & Pratt, A. C. 2002. Managing creativity in the cultural industries. *Creativity and innovation management,* 11(4)**,** 225-233.

Jenkins, A. M., Naumann, J. D. & Wetherbe, J. C. 1984. Empirical investigation of systems development practices and results. *Information and Management,* 7(2)**,** 73-82.

Jiang, Z. N., Peter; Comstock, Craig 2007. An investigation on the variation of software development productivity. *International Journal of Computer, Information, and Systems Sciences, and Engineering,* 1**,** 72–81.

Johnson-Laird, P. N. 1983. *Mental models: Towards a cognitive science of language, inference, and consciousness*, Harvard University Press.

Johnson, D., Watling, C. N., Gardner, J. & Nacke, L. E. 2014. The edge of glory: the relationship between metacritic scores and player experience. *Proceedings of the 1st ACM SIGCHI Annual Symposium on Computer-Human Interaction in Play,* CHI PLAY '14**,** 141-150.

Jones, C. 1996. Careers in project networks: The case of the film industry. *The boundaryless career: A new employment principle for a new organizational era,* 58**,** 75.

Kanter, R. M. 1977. Some Effects of Proportions on Group Life: Skewed Sex Ratios and Responses to Token Women. *American Journal of Sociology***,** 965-990.

Kasurinen, J. Games as software: Similarities and differences between the implementation projects. Proceedings of the 17th International Conference on Computer Systems and Technologies 2016, 2016. ACM, 33-40.

Katz, R. & Allen, T. J. 1982. Investigating the Not Invented Here (NIH) syndrome: A look at the performance, tenure, and communication patterns of 50 R & D Project Groups. *R&d Management,* 12**,** 7-20.

Kemerer, C. F. & Patrick, M. W. 1993. *Staffing factors in software cost estimation models,* New York, NY, McGraw-Hill.

Kerrigan, S., McIntyre, P., Fulton, J. & Meany, M. 2019. The systemic relationship between creative failure and creative success in the creative industries. *Creative Industries Journal***,** 1-15.

Kerzner, H. 2006. *Project Management: A Systems Approach to Planning, Scheduling, and Controlling,* Hoboken, New Jersey, John Wiley & Sons.

Kiley, A. T. 2016. *Indie inclusion?: Analyzing diversity in the independent video game industry.* M.S. Master's Thesis, University of Oregon.

Kim, T. 2018. *Activision Blizzard slumps as Call of Duty sales disappoint* [Online]. Barron's. Available: https://www.barrons.com/articles/activision-blizzard-slumps-as-call-of-duty-sales-disappoint-1539880695 [Accessed March 18th, 2019].

Kochan, T., Bezrukova, K., Ely, R., Jackson, S., Joshi, A., Jehn, K., Leonard, J., Levine, D. & Thomas, D. 2003. The effects of diversity on business performance: Report of the diversity research network. *Human Resource Management: Published in Cooperation with the School of Business Administration, The University of Michigan and in alliance with the Society of Human Resources Management,* 42**,** 3-21.

Kohler, W. P. 2012. *The creative processes in video game development: A model set illustrating the creative processes with theoretical and practical implications.* University of Warwick.

Koster, R. 2018. *The cost of games* [Online]. Available: https://www.raphkoster.com/2018/01/17/the-cost-of-games/ [Accessed July 27th, 2019].

Krätke, S. 2012. *The creative capital of cities: Interactive knowledge creation and the urbanization economies of innovation*, John Wiley & Sons.

Kultima, A. The organic nature of game ideation: game ideas arise from solitude and mature by bouncing. Proceedings of the International Academic Conference on the Future of Game Design and Technology, 2010. 33-39.

Lampel, J., Lant, T. & Shamsie, J. 2000. Balancing act: Learning from organizing practices in cultural industries. *Organization Science,* 11(3)**,** 263-269.

Lampel, J., Shamsie, J. & Lant, T. 2006. Untangling the complexities of cultural industries: Directions for future research. *The Business of Culture: Emerging Perspectives in Media and Entertainment, J. Lampel, J. Shamsie and T. Lant, eds***,** 289-304.

Landaeta, R. E. 2008. Evaluating benefits and challenges of knowledge transfer across projects. *Engineering Management Journal,* 20**,** 29-38.

Lash, S. & Urry, J. 1994. *Economies of signs and space*, Sage.

Leonard-Barton, D. 1992. Core capabilities and core rigidities: A paradox in managing new product development. *Strategic Management Journal,* 13(S1)**,** 111-125.

Leonard-Barton, D. 1995. *Wellsprings of knowledge,* Boston, MA, Harvard Business School Press.

Leonard, D. & Sensiper, S. 1998. The role of tacit knowledge in group innovation. *California management review,* 40**,** 112-132.

Leonard, D. & Swap, W. 2005. Deep smarts. *Harvard business review,* 30**,** 157-169.

Leonard, D. A. 2011. *Managing knowledge assets, creativity and innovation*, World

Scientific.

Leonard, D. A. & Swap, W. 2011. Designing the Psychological Environment. *Managing Knowledge Assets, Creativity And Innovation.* World Scientific.

Levinthal, D. A. & March, J. G. 1993. The myopia of learning. *Strategic management journal,* 14**,** 95-112.

Levitt, B. & March, J. G. 1988. Organizational learning. *Annual review of Sociology,* 14(1)**,** 319-338.

Lewis-Evans, B. 2012. *Finding out what they think: A rough primer to user research* [Online]. Available: http://www.gamasutra.com/view/feature/169069/finding_out_what_they_think_a_.php [Accessed October 18, 2016].

Liao, S. H. 2003. Knowledge management technologies and applications ? Literature review from 1995 to 2002. *Expert Systems with Applications,* 25(2)**,** 155-164.

Lien, T. 2014. *The Fall of THQ* [Online]. Polygon. Available: https://www.polygon.com/covers/2014/12/9/7257209/the-fall-of-thq [Accessed March 18th, 2019].

Lorenzen, M. & Frederiksen, L. 2005. The management of projects and product experimentation: examples from the music industry. *European Management Review,* 2**,** 198-211.

Lundin, R. A. & Norbäck, M. 2016. Projectification in the media industries. *Managing Media Firms and Industries.* Springer.

Lusch, R. F. & Vargo, S. L. 2006. *The service-dominant logic of marketing: Dialog, debate, and directions,* Armonk, New York, M.E. Sharpe.

Maas, V. S. & Torres-Gonzalez, R. 2011. Subjective performance evaluation and gender discrimination. *Journal of Business Ethics,* 101**,** 667-681.

Maier, E. R. & Branzei, O. 2014. "On time and on budget": Harnessing creativity in large scale projects. *International Journal of Project Management,* 32**,** 1123-1133.

Makuch, E. 2018. *Call Of Duty: WW2 And Destiny 2 help Activision Blizzard to a record year* [Online]. Gamespot. Available: https://www.gamespot.com/articles/call-of-duty-ww2-and-destiny-2-help-activision-bli/1100-6456667/ [Accessed January 4th, 2019].

March, J. G. 1991. Exploration and exploitation in organizational learning. *Organization Science,* 2(1)**,** 71-87.

Marchand, A. 2016. The power of an installed base to combat lifecycle decline: The case of video games. *International Journal of Research in Marketing,* 33(1)**,** 140-154.

Markham, S. K., Ward, S. J., Aiman-Smith, L. & Kingon, A. I. 2010. The valley of death as

context for role theory in product innovation. *Journal of Product Innovation Management,* 27(3), 402-417.

Markowitz, E. & Gilat, M. 2015. *More Female Speakers Than Ever at Biggest Gaming Conference* [Online]. Vocativ. Available: https://www.vocativ.com/tech/internet/gamergate-female-gamers-gdc-conference/index.html [Accessed February 2nd, 2019].

Marshall, A. 1920. *Principles of Economics,* London, Macmillan and Co.

Matei, G. 2010. A collaborative approach of business intelligence systems. *Journal of Applied Collaborative Systems,* 2(2), 91-101.

Mathew, M., Grossman, J. & Andreopoulou, A. Women in Audio: contributions and challenges in music technology and production. Audio Engineering Society Convention 141, 2016. Audio Engineering Society.

McCaffery, E. J. 1993. Slouching Towards Equality: Gender Discrimination, Market Efficiency, and Social Change. *The Yale Law Journal,* 103, 595-675.

McClintock, P. 2017. *2017 Box Office: Global Revenue Hits Record $40B Even as Movie Attendance Plummets in U.S.* [Online]. The Hollywood Reporter. Available: https://www.hollywoodreporter.com/news/2017-box-office-global-revenue-hits-record-40b-as-movie-attendance-plummets-us-1070879 [Accessed January 13th, 2019].

McRobbie, A. 2002. Clubs to companies: Notes on the decline of political culture in speeded up creative worlds. *Cultural studies,* 16, 516-531.

Metacritic. 2018. *How we create the Metascore magic* [Online]. CBS Interactive, Inc. Available: http://www.metacritic.com/about-metascores [Accessed April 30, 2018 2018].

Metacritic. 2020. *About - Metacritic* [Online]. CBS Interactive, Inc. Available: https://www.metacritic.com/about-metacritic [Accessed March 21st, 2020].

Mills, B. & Horton, E. 2016. *Creativity in the British Television Comedy Industry*, Taylor & Francis.

Murphy-Hill, E., Zimmermann, T. & Nagappan, N. 2014. Cowboys, ankle sprains, and keepers of quality: How is video game development different from software development? *Proceedings of the 36th International Conference on Software Engineering*, 1-11.

Musil, J., Schweda, A., Winkler, D. & Biffl, S. 2010. A survey on the state of the practice in video game software development. *Technical Report No. IFS-QSE 10/04.*

National Women's Law Center. 2018. *Requiring Transparency Around Salary Ranges Reduces the Gender Wage Gap* [Online]. National Women's Law Center. Available: https://nwlc-ciw49tixgw5lbab.stackpathdns.com/wp-content/uploads/2018/06/Requir

ing-Transparency-around-Salary-Ranges-Reduces-the-Gender-Wage-Gap-FINAL.pdf [Accessed May 30th, 2019].

Negus, K. 1992. *Producing pop: Culture and conflict in the popular music industry*, E. Arnold London.

Newzoo 2018. Top 25 Public Companies by Game Revenues. Newzoo.

Newzoo. 2019. *Global games market report* [Online]. Newzoo. Available: https://newzoo.com/solutions/standard/market-forecasts/global-games-market-report/ [Accessed July 27th, 2019].

Nintendo. 2018. *CSR Report 2018: Maximizing Our Employees' Strengths* [Online]. Nintendo. Available: https://www.nintendo.co.jp/csr/en/report2018/employees/index.html [Accessed January 13th, 2019].

Nonaka, I. 1991. The knowledge-creating company. *Harvard Business Review,* 69(6), 96?104.

Nonaka, I. 1994. A dynamic theory of organizational knowledge creation. *Organization Science,* 5(1), 14-37.

Nonaka, I., Toyama, R. & Hirata, T. 2008. *Managing flow: A process of theory of the knowledge-based firm*, Springer.

Nozhnin, D. 2012. *Predicting churn: Data-mining your game* [Online]. Available: http://www.gamasutra.com/view/feature/170472/predicting_churn_datamining_your_.php [Accessed October 19, 2016].

O'Donnell, C. 2014. *Developer's dilemma: The secret world of videogame creators*, MIT press.

Oakley, K. 2009. *'Art Works'-Cultural Labour Markets: A Literature Review*, Creativity, Culture and Education London.

Ordanini, A., Rubera, G. & DeFillippi, R. 2008. The many moods of inter - organizational imitation: A critical review. *International Journal of Management Reviews,* 10(4), 375-398.

Østergaard, C. R., Timmermans, B. & Kristinsson, K. 2011. Does a different view create something new? The effect of employee diversity on innovation. *Research policy,* 40, 500-509.

Paaßen, B., Morgenroth, T. & Stratemeyer, M. 2017. What is a true gamer? The male gamer stereotype and the marginalization of women in video game culture. *Sex Roles,* 76, 421-435.

Parkin, S. 2018. *The great video game exodus* [Online]. Gamasutra. Available: https://www.gamasutra.com/view/news/318588/The_great_video_game_exodus.php [Accessed August 8th, 2019].

Parmentier, G. & Picq, T. 2016. Managing creative teams in small ambidextrous organizations: The case of videogames. *International Journal of Arts Management,* 19(1), 16-30.

Parrotta, P., Pozzoli, D. & Pytlikova, M. 2014. The nexus between labor diversity and firm's innovation. *Journal of Population Economics,* 27, 303-364.

Pass, S. & Ronen, B. 2014. Reducing the software value gap. *Communications of the ACM,* 57(5), 80-87.

Paulk, M. C., Curtis, B., Chrissis, M. B. & Weber, C. V. 1993. Capability Maturity Model, version 1.1. *IEEE Software,* 10(4), 18-27.

Pearson, D. 2014. *Shovel Knight devs break down costs, sales* [Online]. Available: http://www.gamesindustry.biz/articles/2014-08-06-shovel-knight-devs-break-down-costs-sales [Accessed August 28, 2017].

Peltoniemi, M. 2008. Life-cycle of the games industry. *Proceedings of the 12th International Conference on Entertainment and Media in the Ubiquitous Era,* MindTrek '08, 54-58.

Peltoniemi, M. 2009a. Entrepreneurship and innovation within creative industries: a case study on the Finnish games industry. *International Journal of Entrepreneurship and Small Business,* 7, 420-430.

Peltoniemi, M. 2009b. *Industry life-cycle theory in the cultural domain: Dynamics of the games industry.* Doctor of Technology, Tampere University of Technology.

Peltoniemi, M. 2015. Cultural industries: Product–market characteristics, management challenges and industry dynamics. *International journal of management reviews,* 17, 41-68.

Perretti, F. & Negro, G. 2007. Mixing genres and matching people: A study in innovation and team composition in Hollywood. *Journal of Organizational Behavior: The International Journal of Industrial, Occupational and Organizational Psychology and Behavior,* 28, 563-586.

Petrillo, F., Pimenta, M., Trindade, F. & Dietrich, C. 2008. Houston, we have a problem...: A survey of actual problems in computer games development. *Proceedings of the 2008 ACM Symposium on Applied Computing,* SAC '08, 707-711.

Pfeffer, J. & Sutton, R. I. 2006. Evidence-based management. *Harvard business review,* 84(1), 62-74.

Phillips, B. 2010. Peering into the black box of player behavior: The player experience panel at Microsoft Game Studios. *Proceedings of Game Developer's Conference 2010.*

Polanyi, M. 2012. *Personal knowledge*, Routledge.

Popper, K. 1959. *The logic of scientific discovery*, Routledge.

Popper, K. 1979. *Three worlds*, Ann Arbor,: University of Michigan.

Popper, K. R. 1963. Science as falsification. *Conjectures and refutations,* 1**,** 33-39.

Potanin, R. Forces in play: The business and culture of videogame production. Proceedings of the 3rd International Conference on Fun and Games, 2010. 135-143.

Pratto, F., Stallworth, L. M., Sidanius, J. & Siers, B. 1997. The gender gap in occupational role attainment: a social dominance approach. *Journal of personality and social psychology,* 72**,** 37.

Prendergast, C. & Topel, R. 1993. Discretion and bias in performance evaluation. *European Economic Review,* 37**,** 355-365.

Prichard, C. 2002. Creative selves? Critically reading 'creativity'in management discourse. *Creativity and Innovation Management,* 11**,** 265-276.

Project Management Institute 2017. *A guide to the project management body of knowledge (PMBOK guide),* Newtown Square, Pennsylvania, Project Management Institute, Inc.

Rangarajan, S. 2018. *Here's the clearest picture of Silicon Valley's diversity yet: It's bad. But some companies are doing less bad* [Online]. Reveal. Available: https://www.revealnews.org/article/heres-the-clearest-picture-of-silicon-valleys-diversity-yet/ [Accessed January 4th, 2019].

Rayna, T. & Striukova, L. 2014. 'Few to Many': Change of Business Model Paradigm in the Video Game Industry. *Digiworld Economic Journal***,** 61.

Readman, J. & Grantham, A. 2006. Shopping for Buyers of Product Development Expertise: How Video Games Developers Stay Ahead. *European Management Journal,* 24(4)**,** 256-269.

Rerup, C. & Feldman, M. A. 2011. Routines as a source of change in organizational schemata: The role of trial-and-error learning. *Academy of Management Journal,* 54(3)**,** 577-610.

Riot Games. 2019. *10 Year Anniversary Press Release* [Online]. Riot Games. Available: https://www.riotgames.com/darkroom/original/305877d56661fc59b724a0035f9b7277:2d6eb23488c67393e4d410e47bbf91d8/l10-press-release.pdf [Accessed March 22nd, 2020].

Robbins, L. 1932. *An essay on the nature and significance of economic science,* London, MacMillan & Co., Ltd.

Ronen, B. & Pass, S. 2008. *Focused operations management: Achieving more with existing resources*, John Wiley & Sons.

Ruth Eikhof, D. & Warhurst, C. 2013. The promised land? Why social inequalities are systemic in the creative industries. *Employee Relations,* 35**,** 495-508.

Sambuchino, C. 2016. *Word Count for Novels and Children's Books: The Definitive Post* [Online]. Writer's Digest: Writer's Digest. Available: https://www.writersdigest.com/guest-columns/word-count-for-novels-and-childrens-books-the-definitive-post [Accessed March 27th, 2020].

Sapsed, J., Grantham, A. & DeFillippi, R. 2007. A bridge over troubled waters: Bridging organisations and entrepreneurial opportunities in emerging sectors. *Research Policy,* 36**,** 1314-1334.

Schneider, B. 1987. The people make the place. *Personnel psychology,* 40**,** 437-453.

Scholz, T. M. 2012. Talent management in the video game industry: The role of cultural diversity and cultural intelligence. *Thunderbird International Business Review,* 54**,** 845-858.

Schreier, J. 2011. *THQ Shares Drop After 'Average' Homefront Reviews* [Online]. Wired.com: Wired.com. Available: https://www.wired.com/2011/03/thq-homefront-stock-drop/ [Accessed March 26th, 2020].

Schreier, J. 2017a. *Top Video Game Companies Won't Stop Talking About 'Games as a Service'* [Online]. Kotaku. Available: https://kotaku.com/top-video-game-companies-wont-stop-talking-about-games-1795663927 [Accessed March 22nd, 2020].

Schreier, J. 2017b. *Why video games cost so much to make* [Online]. Kotaku. Available: https://kotaku.com/why-video-games-cost-so-much-to-make-1818508211 [Accessed January 4th, 2019].

Scott, R. F. & Simmons, D. B. 1975. Predicting programming group productivity: A communications model. *IEEE Transactions on Software Engineering,* 1(4)**,** 411-414.

Shirinian, A. 2011. *Dissecting the postmortem: Lessons learned from two years of game development self-reportage* [Online]. Available: http://www.gamasutra.com/view/feature/134679/dissecting_the_postmortem_lessons_.php [Accessed August 5, 2016].

Sifa, R., Bauckhage, C. & Drachen, A. 2014. The playtime principle: Large-scale cross-games interest modeling. *2014 IEEE Conference on Computational Intelligence and Games (CIG).*

Simon, H. A. 1957. *Models of Man,* New York, Wiley.

Simon, H. A. 1972. Theories of Bounded Rationality. *In:* MCGUIRE, C. B. & RADNER, R. (eds.) *Decision and Organization: A Volume in Honor of Jacob Marschak.* North-Holland Publishing Company.

Simonton, D. K. 2000. Creative development as acquired expertise: Theoretical issues and an empirical test. *Developmental Review,* 20**,** 283-318.

Situmeang, F. B. I., Leenders, M. A. A. M. & Wijnberg, N. M. 2014. The good, the bad and the variable: How evaluations of past editions influence the success of sequels. *European Journal of Marketing,* 48**,** 1466-1486.

Smith, J. H. Playing dirty-understanding conflicts in multiplayer games. 5th annual conference of The Association of Internet Researchers, 2004.

Smith, S. L., Choueiti, M., Pieper, K., Case, A. & Choi, A. 2018. Inequality in 1,100 Popular Films: Examining Portrayals of Gender, Race/Ethnicity, LGBT & Disability from 2007 to 2017. Annenberg Foundation.

Taylor, H. 2017. *Global gaming revenue on par with sports at $149bn for 2017* [Online]. gamesindustry.biz. Available: https://www.gamesindustry.biz/articles/2017-11-28-global-gaming-revenue-on-par-with-sports-following-2017-estimates [Accessed January 13th, 2017].

Thaler, R. 1980. Toward a positive theory of consumer choice. *Journal of Economic Behavior & Organization,* 1(1)**,** 39-60.

The NPD Group. 2019. *US Market Research* [Online]. The NPD Group. Available: http://www.npd.com/wps/portal/npd/us/worldwide/united-states/ [Accessed April 18th, 2019].

Townley, B., Beech, N. & McKinlay, A. 2009. Managing in the creative industries: Managing the motley crew. *Human relations,* 62**,** 939-962.

Tschang, F. T. 2007. Balancing the tensions between rationalization and creativity in the video games industry. *Organization Science,* 18(6)**,** 989-1005.

Tschang, F. T. 2010. The interaction of roles, resources, and organizational structures in creative work. *DRUID Summer Conference 2010 on Opening Up Innovation: Strategy, Organization and Technology.* London.

Tsoukas, H. 2003. Do we really understand tacit knowledge? *In:* EASTERBY-SMITH, M. & LYLES, M. A. (eds.) *The Blackwell Handbook of Organizational Knowledge Management.* Oxford: Blackwell.

Tuomi, I. 1999. Data is more than knowledge: Implications of the reversed knowledge hierarchy for knowledge management and organizational memory. *Proceedings of the 32nd Annual Hawaii International Conference on Systems Sciences, 1999,* HICSS-32.

Tversky, A. & Kahneman, D. 1979. Prospect theory: An analysis of decision under risk. *Econometrica,* 47**,** 263-291.

Valve Corporation. 2018. *Best of 2017: Top sellers* [Online]. Available: https://store.steampowered.com/sale/2017_best_sellers/ [Accessed April 30, 2018 2018].

van den Akker, M., Brinkkemper, S., Diepen, G. & Versendaal, J. 2008. Software product release planning through optimization and what-if analysis. *Information and Software Technology,* 50(1-2), 101-111.

Vargo, S. L. & Lusch, R. F. 2004. Evolving to a new dominant logic for marketing. *Journal of Marketing,* 68(1), 1-17.

VGChartz. 2019. *VGChartz Methodology* [Online]. VGChartz. Available: http://www.vgchartz.com/methodology.php [Accessed April 18th, 2019].

Vosburgh, J. A., Curtis, B., Wolverton, R., Albert, B., Malec, H., Hoben, S. & Liu, Y. 1984. Productivity factors and programming environments. *Proceedings of the 7th International Conference on Software Engineering*, 143-152.

Wada, T., Ichikohji, T. & Ikuine, F. 2014. Platform paradox. *Annals of Business Administrative Science,* 13, 91-103.

Wade, A. The State of the Art: Western Modes of Videogame Production. DiGRA Conference, 2007.

Walls, W. D. 2009. Screen wars, star wars, and sequels. *Empirical Economics,* 37, 447-461.

Washburn, M. J., Sathiyanarayanan, P., Nagappan, M., Zimmerman, T. & Bird, C. 2016. What went right and what went wrong: An analysis of 155 postmortems from game development. *Proceedings of the 38th International Conference on Software Engineering Companion, 2016,* ICSE '16, 280-289.

Wawro, A. 2016. *Steam Spy: Over a third of all steam games were released this year* [Online]. Available: http://www.gamasutra.com/view/news/286644/Steam_Spy_Over_a_third_of_all_Steam_games_were_released_this_year.php [Accessed December 13, 2016].

Weber, B. G., John, M., Mateas, M. & Jhala, A. 2011a. Modeling player retention in Madden NFL 11. *Proceedings of the Twenty-Third Conference on Innovative Applications of Artificial Intelligence*.

Weber, B. G., Mateas, M. & Jhala, A. 2011b. Using data mining to model player experience. *FDG 2011 Workshop on Evaluating Player Experience in Games.*

Webster, T. J. 2003. *Managerial economics: Theory and practice*, Academic Press.

Weick, K. E. 1995. *Sensemaking in organizations*, Sage Publications.

Weisberg, R. W. 1993. *Creativity: Beyond the myth of genius*, WH Freeman.

Weststar, J., O'Meara, V. & Legault, M.-J. 2018. Developer Satisfaction Survey 2017 Summary Report. International Game Developers Association (IGDA).

Wiegers, K. E. 1999. First things first: Prioritizing requirements. *Software Development,* 7(9), 48-53.

Wierzbicki, A. P. & Nakamori, Y. 2005. *Creative space: Models of creative processes for the*

knowledge civilization age, Springer Science & Business Media.

Wijman, T. 2018. *Top 25 public game companies earn $94.1 billion in 2017* [Online]. Newzoo. Available: https://newzoo.com/insights/articles/top-25-public-game-companies-earn-94-1-billion-in-2017/ [Accessed January 4th, 2019].

Wijman, T. 2019. *The global games market will generate $152.1 billion in 2019 as the U.S. overtakes China as the biggest market* [Online]. Newzoo. Available: https://newzoo.com/insights/articles/the-global-games-market-will-generate-152-1-billion-in-2019-as-the-u-s-overtakes-china-as-the-biggest-market/ [Accessed July 27th, 2019].

Williams, D., Martins, N., Consalvo, M. & Ivory, J. D. 2009. The virtual census: Representations of gender, race and age in video games. *New Media & Society,* 11**,** 815-834.

Williams, K. Y. & O'Reilly III, C. A. 1998. Demography and diversity in organizations: A review of 40 years of research. *Research in organizational behavior,* 20**,** 77-140.

Wilson, N. 2009. Learning to manage creativity: an occupational hazard for the UK's creative industries. *Creative Industries Journal,* 2.

Wilson, T. D. 2002. The nonsense of knowledge management. *Information Research,* 8(1).

Woodruff, R. B. 1997. Customer value: The next source for competitive advantage. *Journal of the Academy of Marketing Science,* 25(2)**,** 139-153.

xPaw & Marlamin. 2018. *Steam online charts: Concurrent steam users* [Online]. Available: https://steamdb.info/graph/ [Accessed April 30, 2018 2018].

Yee, N. 2017. *Beyond 50/50: Breaking Down The Percentage of Female Gamers by Genre* [Online]. Quantic Foundry. Available: https://quanticfoundry.com/2017/01/19/female-gamers-by-genre/ [Accessed January 4th, 2019].

Yoon, A. 2009. *Guitar Hero, Rock Band sales slide reminiscent of DDR* [Online]. engadget. Available: https://www.engadget.com/2009/07/22/guitar-hero-rock-band-sales-slide-reminiscent-of-ddr/ [Accessed January 4th, 2019].

Yourdon, E. 1995. When good enough software is best. *IEEE Software,* 12(3)**,** 79-81.

Zimmermann, T., Phillips, B., Nagappan, N. & Harrison, C. 2012. Data-driven games user research. *CHI Workshop on Game User Research,* CHI-GUR 2012**,** 1-4.

Appendix A. Data Tables

Table A-1. The detailed breakdown of original IP games versus games based on prior IP for each publisher in the sample by year for the period from 1980 to 2018.

Year	Activision Blizzard		EA		Bandai Namco		Take Two		Square Enix	
	New	All	New	All	New	All	New	All	New	All
1980	6 (100%)	6	-	-	6 (100%)	6	-	-	-	-
1981	6 (100%)	6	-	-	2 (50%)	4	-	-	-	-
1982	10 (100%)	10	-	-	3 (60%)	5	-	-	-	-
1983	16 (100%)	16	8 (89%)	9	4 (57%)	7	-	-	-	-
1984	12 (86%)	14	4 (80%)	5	3 (38%)	8	-	-	1 (100%)	1
1985	11 (100%)	11	7 (70%)	10	4 (40%)	10	-	-	3 (60%)	5
1986	13 (76%)	17	10 (67%)	15	7 (54%)	13	-	-	6 (100%)	6
1987	11 (79%)	14	9 (75%)	12	6 (50%)	12	-	-	8 (53%)	15
1988	11 (85%)	13	19 (76%)	25	15 (88%)	17	-	-	3 (50%)	6
1989	10 (56%)	18	13 (62%)	21	9 (53%)	17	-	-	0 (0%)	2
1990	6 (86%)	7	14 (70%)	20	5 (38%)	13	-	-	1 (20%)	5
1991	4 (57%)	7	6 (38%)	16	3 (20%)	15	-	-	0 (0%)	4
1992	3 (33%)	9	7 (35%)	20	7 (41%)	17	-	-	4 (50%)	8
1993	2 (40%)	5	13 (50%)	26	10 (50%)	20	-	-	7 (70%)	10
1994	5 (56%)	9	15 (44%)	34	6 (46%)	13	2 (67%)	3	4 (50%)	8
1995	1 (6%)	17	12 (40%)	30	8 (44%)	18	1 (50%)	2	8 (57%)	14
1996	7 (54%)	13	7 (24%)	29	9 (47%)	19	3 (60%)	5	15 (63%)	24
1997	6 (32%)	19	11 (27%)	41	5 (42%)	12	2 (33%)	6	16 (48%)	33
1998	5 (25%)	20	8 (20%)	41	8 (73%)	11	7 (33%)	21	18 (51%)	35
1999	4 (17%)	24	8 (17%)	47	7 (39%)	18	14 (42%)	33	16 (36%)	45
2000	2 (7%)	27	10 (17%)	58	7 (35%)	20	29 (53%)	55	15 (38%)	39
2001	4 (13%)	31	10 (23%)	43	3 (19%)	16	25 (52%)	48	17 (46%)	37

2002	5 (17%)	30	11 (20%)	54	7 (32%)	22	18 (47%)	38	13 (33%)	39
2003	6 (23%)	26	1 (2%)	48	4 (29%)	14	14 (30%)	46	6 (21%)	28
2004	1 (4%)	23	2 (5%)	37	3 (21%)	14	16 (32%)	50	4 (27%)	15
2005	2 (9%)	22	2 (4%)	51	4 (16%)	25	7 (16%)	43	7 (30%)	23
2006	0 (0%)	23	2 (5%)	38	4 (10%)	41	5 (16%)	31	3 (10%)	31
2007	0 (0%)	23	10 (20%)	49	2 (6%)	35	5 (19%)	26	8 (24%)	33
2008	1 (4%)	26	10 (17%)	59	5 (18%)	28	0 (0%)	20	10 (34%)	29
2009	2 (7%)	27	8 (12%)	66	6 (18%)	34	5 (20%)	25	8 (24%)	34
2010	4 (15%)	26	5 (8%)	66	7 (23%)	31	1 (7%)	14	4 (17%)	24
2011	1 (5%)	19	6 (14%)	42	5 (17%)	30	2 (13%)	16	4 (21%)	19
2012	0 (0%)	20	3 (7%)	46	6 (21%)	28	1 (4%)	23	7 (37%)	19
2013	0 (0%)	13	1 (3%)	29	7 (21%)	34	0 (0%)	19	2 (15%)	13
2014	1 (6%)	16	1 (7%)	14	5 (15%)	34	0 (0%)	8	3 (17%)	18
2015	1 (10%)	10	0 (0%)	18	5 (25%)	20	1 (9%)	11	3 (27%)	11
2016	1 (17%)	6	1 (6%)	16	1 (5%)	22	1 (5%)	20	4 (17%)	23
2017	0 (0%)	3	0 (0%)	10	6 (18%)	34	0 (0%)	9	3 (13%)	24
2018	0 (0%)	4	2 (17%)	12	2 (11%)	19	0 (0%)	8	5 (26%)	19
Total	180	630	256	1157	216	756	159	580	236	699
	Ubisoft		Warner Bros.		Konami		Midway		THQ	
	New	All	New	All	New	All	New	All	New	All
1980	-	-	-	-	-	-	1 (100%)	1	-	-
1981	-	-	-	-	1 (100%)	1	2 (100%)	2	-	-
1982	-	-	-	-	2 (100%)	2	2 (67%)	3	-	-
1983	-	-	-	-	6 (86%)	7	3 (50%)	6	-	-
1984	-	-	-	-	9 (69%)	13	2 (100%)	2	-	-
1985	-	-	-	-	13 (81%)	16	1 (100%)	1	-	-
1986	3 (100%)	3	-	-	9 (47%)	19	1 (100%)	1	-	-
1987	10 (83%)	12	-	-	19 (66%)	29	1 (50%)	2	-	-
1988	5	5	-	-	10	24	1	1	-	-

	(100%)				(42%)		(100%)				
1989	11 (100%)	11	-	-	8 (36%)	22	1 (100%)	1	-	-	
1990	4 (57%)	7	-	-	4 (17%)	23	2 (100%)	2	-	-	
1991	1 (20%)	5	-	-	8 (28%)	29	1 (100%)	1	1 (17%)	6	
1992	0 (0%)	1	-	-	5 (19%)	27	2 (100%)	2	0 (0%)	7	
1993	0 (0%)	3	-	-	7 (30%)	23	0 (0%)	2	0 (0%)	4	
1994	2 (67%)	3	-	-	5 (21%)	24	0 (0%)	2	0 (0%)	2	
1995	3 (100%)	3	-	-	2 (13%)	16	0 (0%)	4	-	-	
1996	1 (50%)	2	-	-	10 (34%)	29	1 (17%)	6	1 (100%)	1	
1997	4 (57%)	7	-	-	3 (14%)	21	2 (25%)	8	1 (11%)	9	
1998	7 (58%)	12	-	-	12 (32%)	38	5 (50%)	10	2 (25%)	8	
1999	2 (18%)	11	-	-	15 (26%)	58	2 (25%)	8	2 (15%)	13	
2000	5 (26%)	19	-	-	4 (6%)	64	2 (12%)	17	1 (5%)	19	
2001	10 (30%)	33	-	-	8 (15%)	54	2 (18%)	11	4 (17%)	23	
2002	6 (17%)	36	-	-	4 (8%)	52	5 (38%)	13	3 (7%)	41	
2003	8 (32%)	25	-	-	4 (9%)	44	4 (31%)	13	5 (13%)	38	
2004	4 (17%)	24	-	-	4 (8%)	50	2 (29%)	7	2 (8%)	26	
2005	6 (20%)	30	0 (0%)	3	7 (13%)	53	1 (9%)	11	4 (15%)	26	
2006	9 (28%)	32	0 (0%)	2	6 (11%)	54	1 (8%)	13	5 (17%)	29	
2007	7 (15%)	46	0 (0%)	3	11 (18%)	62	4 (36%)	11	3 (8%)	36	
2008	13 (27%)	48	0 (0%)	4	6 (17%)	35	1 (14%)	7	8 (24%)	34	
2009	6 (15%)	40	1 (7%)	15	10 (31%)	32	-	-	5 (22%)	23	
2010	7 (21%)	33	1 (7%)	14	6 (16%)	37	-	-	10 (38%)	26	
2011	8 (19%)	43	1 (6%)	18	2 (7%)	27	-	-	6 (19%)	31	
2012	6 (21%)	28	1 (6%)	16	6 (38%)	16	-	-	0 (0%)	5	
2013	3 (12%)	25	0 (0%)	17	0 (0%)	5	-	-	-	-	
2014	6 (30%)	20	0 (0%)	13	0 (0%)	3	-	-	-	-	
2015	1	22	1	15	0	5	-	-	-	-	

	(5%)		(7%)		(0%)					
2016	3 (16%)	19	0 (0%)	14	0 (0%)	4	-	-	-	-
2017	2 (12%)	17	0 (0%)	7	0 (0%)	5	-	-	-	-
2018	4 (20%)	20	0 (0%)	11	0 (0%)	5	-	-	-	-
Total	167	645	5	152	226	1028	52	168	63	407

Table A-2. The list of top-ten selling games from 2001 - 2018 according to *The NPD Group* with a flag indicating whether the game is a sequel along with how old the IP franchise is at the time it enters the list.

Year	Rank	Name	Publisher	Non-Game Franchise	Sequel	Franchise Age
2001	1	Grand Theft Auto III	Take Two		Y	4
2001	2	Madden NFL 2002	Electronic Arts	John Madden, NFL	Y	13
2001	3	Pokemon Crystal	Nintendo		Y	5
2001	4	Metal Gear Solid 2	Konami		Y	14
2001	5	Super Mario Advance	Nintendo		Y	16
2001	6	Gran Turismo 3: A-Spec	SCE	Actual Cars	Y	4
2001	7	Tony Hawk's Pro Skater 3	Activision		Y	2
2001	8	Tony Hawk's Pro Skater 2	Activision		Y	2
2001	9	Pokemon Silver	Nintendo		Y	5
2001	10	Driver 2	Infogrames		Y	2
2002	1	Grand Theft Auto: Vice City	Take Two		Y	5
2002	2	Grand Theft Auto III	Take Two		Y	5
2002	3	Madden NFL 2003	Electronic Arts	John Madden, NFL	Y	14
2002	4	Super Mario Advance 2	Nintendo		Y	17
2002	5	Gran Turismo 3: A-Spec	SCE	Actual Cars	Y	5
2002	6	Medal of Honor: Frontline	Electronic Arts		Y	3
2002	7	Spider-Man: The Movie	Activision	Spider-Man	N	0
2002	8	Kingdom Hearts	Square Enix	Disney	N	0
2002	9	Halo	Microsoft		N	0
2002	10	Super Mario Sunshine	Nintendo		Y	17
2003	1	Madden NFL 2004	Electronic Arts	John Madden, NFL	Y	15
2003	2	Pokemon Ruby	Nintendo		Y	7
2003	3	Pokemon Sapphire	Nintendo		Y	7
2003	4	Need for Speed: Underground	Electronic Arts		Y	9
2003	5	Zelda: The Wind Waker	Nintendo		Y	17

2003	6	Grand Theft Auto: Vice City	Take Two		Y	6
2003	7	Mario Kart: Double Dash	Nintendo		Y	18
2003	8	Tony Hawk Underground	Activision	Tony Hawk	Y	4
2003	9	Enter the Matrix	Atari	Matrix	N	0
2003	10	Medal of Honor: Rising Sun	Electronic Arts		Y	4
2004	1	Grand Theft Auto: San Andreas	Take Two		Y	7
2004	2	Halo 2	Microsoft		Y	2
2004	3	Madden NFL 2005	Electronic Arts	John Madden, NFL	Y	16
2004	4	ESPN NFL 2K5	Sega	ESPN, NFL	Y	5
2004	5	Need for Speed: Underground 2	Electronic Arts		Y	10
2004	6	Pokemon Fire Red	Nintendo		Y	8
2004	7	NBA Live 2005	Electronic Arts	NBA	Y	10
2004	8	Spider-Man 2	Activision	Spider-Man	Y	2
2004	9	Halo: Combat Evolved	Microsoft		N	2
2004	10	ESPN NFL 2K5	Sega	ESPN, NFL	Y	5
2005	1	Madden NFL 06	Electronic Arts	John Madden, NFL	Y	17
2005	2	Pokemon Emerald	Nintendo		Y	9
2005	3	Gran Turismo 4	SCE	Actual Cars	Y	8
2005	4	Madden NFL 06	Electronic Arts	John Madden, NFL	Y	17
2005	5	NCAA Football 06	Electronic Arts	NCAA	Y	12
2005	6	Star Wars: Battlefront II	Lucas Arts	Star Wars	Y	1
2005	7	MVP Baseball 2005	Electronic Arts	MLB	Y	2
2005	8	Star Wars Episode III: Revenge of the Sith	Lucas Arts	Star Wars	N	0
2005	9	NBA Live 06	Electronic Arts	NBA	Y	11
2005	10	LEGO Star Wars	Eidos	Lego, Star Wars	N	0
2006	1	Madden NFL 07	Electronic Arts	John Madden, NFL	Y	18
2006	2	New Super Mario Bros.	Nintendo		Y	21
2006	3	Gears of War	Microsoft		N	0
2006	4	Kingdom Hearts II	Square Enix	Disney	Y	4
2006	5	Guitar Hero II	Activision	Music	Y	1
2006	6	Final Fantasy XII	Square Enix		Y	19
2006	7	Brain Age: Train Your Brain	Nintendo	Ryuta Kawashima	N	0
2006	8	Madden NFL 07	Electronic Arts	John Madden, NFL	Y	18
2006	9	Ghost Recon: Advanced Warfighter	Ubisoft	Tom Clancy	Y	5
2006	10	NCAA Football 07	Electronic Arts	NCAA	Y	13
2007	1	Halo 3	Microsoft		Y	5
2007	2	Wii Play	Nintendo		N	0

2007	3	Call of Duty 4: Modern Warfare	Activision		Y	4
2007	4	Guitar Hero III: Legends of Rock	Activision	Music	Y	2
2007	5	Super Mario Galaxy	Nintendo		Y	22
2007	6	Pokemon Diamond	Nintendo		Y	11
2007	7	Madden NFL 08	Electronic Arts	John Madden, NFL	Y	19
2007	8	Guitar Hero II	Activision	Music	Y	2
2007	9	Assassin's Creed	Ubisoft		N	0
2007	10	Mario Party 8	Nintendo		Y	22
2008	1	Wii Play	Nintendo		N	0
2008	2	Mario Kart Wii	Nintendo		Y	16
2008	3	Wii Fit	Nintendo		N	0
2008	4	Super Smash Bros. Brawl	Nintendo		Y	9
2008	5	Grand Theft Auto IV	Take Two		Y	11
2008	6	Call of Duty: World at War	Activision		Y	5
2008	7	Gears of War 2	Microsoft		Y	2
2008	8	Grand Theft Auto IV	Take Two		Y	11
2008	9	Madden NFL 09	Electronic Arts	John Madden, NFL	Y	20
2008	10	Mario Kart DS	Nintendo		Y	16
2009	1	Call of Duty: Modern Warfare 2	Activision		Y	6
2009	2	Wii Sports Resort	Nintendo		Y	3
2009	3	New Super Mario Bros. Wii	Nintendo		Y	24
2009	4	Wii Fit	Nintendo		N	1
2009	5	Wii Fit Plus	Nintendo		Y	1
2009	6	Mario Kart Wii	Nintendo		Y	17
2009	7	Wii Play	Nintendo		N	1
2009	8	Call of Duty: Modern Warfare 2	Activision		Y	6
2009	9	Halo 3: ODST	Microsoft		Y	7
2009	10	Pokemon Platinum	Nintendo		Y	13
2010	1	Call of Duty: Black Ops	Activision		Y	7
2010	2	Madden NFL 11	Electronic Arts	John Madden, NFL	Y	22
2010	3	Halo: Reach	Microsoft		Y	8
2010	4	New Super Mario Bros. Wii	Nintendo		Y	25
2010	5	Red Dead Redemption	Take Two		Y	6
2010	6	Wii Fit Plus	Nintendo		Y	2
2010	7	Just Dance 2	Ubisoft	Music	Y	1
2010	8	Call of Duty: Modern Warfare 2	Activision		Y	7
2010	9	Assassin's Creed: Brotherhood	Ubisoft		Y	3
2010	10	NBA 2K11	2K	NBA	Y	11
2011	1	Call of Duty: Modern Warfare 3	Activision		Y	8

2011	2	Just Dance 3	Ubisoft	Music	Y	2
2011	3	Elder Scrolls V: Skyrim	Bethesda		Y	17
2011	4	Battlefield 3	Electronic Arts		Y	9
2011	5	Madden NFL 12	Electronic Arts	John Madden, NFL	Y	23
2011	6	Call of Duty: Black Ops	Activision		Y	8
2011	7	Batman: Arkham City	Warner Bros.	Batman	Y	2
2011	8	Gears of War 3	Microsoft		Y	5
2011	9	Just Dance 2	Ubisoft	Music	Y	2
2011	10	Assassin's Creed: Revelations	Ubisoft		Y	4
2012	1	Call of Duty: Black Ops II	Activision		Y	9
2012	2	Madden NFL 13	Electronic Arts	John Madden, NFL	Y	24
2012	3	Halo 4	Microsoft		Y	10
2012	4	Assassin's Creed III	Ubisoft		Y	5
2012	5	Just Dance 4	Ubisoft	Music	Y	3
2012	6	NBA 2K13	2K	NBA	Y	13
2012	7	Borderlands 2	2K		Y	3
2012	8	Call of Duty: Modern Warfare 3	Activision		Y	9
2012	9	Lego Batman 2: DC Super Heroes	Warner Bros.	Lego, Batman	Y	7
2012	10	FIFA 13	Electronic Arts	FIFA	Y	19
2013	1	Grand Theft Auto V	Take Two		Y	16
2013	2	Call of Duty: Ghosts	Activision		Y	10
2013	3	Madden NFL 25	Electronic Arts	John Madden, NFL	Y	25
2013	4	Battlefield 4	Electronic Arts		Y	11
2013	5	Assassin's Creed IV: Black Flag	Ubisoft		Y	6
2013	6	NBA 2K14	2K	NBA	Y	14
2013	7	Call of Duty: Black Ops II	Activision		Y	10
2013	8	Just Dance 2014	Ubisoft	Music	Y	4
2013	9	Minecraft	Mojang		N	2
2013	10	Disney Infinity	Disney Interactive Studios	Disney	N	0
2014	1	Call of Duty: Advanced Warfare	Activision		Y	11
2014	2	Madden NFL 15	Electronic Arts	John Madden, NFL	Y	26
2014	3	Destiny	Activision		N	0
2014	4	Grand Theft Auto V	Take Two		Y	17
2014	5	Minecraft	Mojang		N	3
2014	6	Super Smash Bros.	Nintendo	Video Game Characters	Y	15
2014	7	NBA 2K15	2K	NBA	Y	15
2014	8	Watch Dogs	Ubisoft		N	0
2014	9	FIFA 15	Electronic Arts	FIFA	Y	21
2014	10	Call of Duty: Ghosts	Activision		Y	11

2015	1	Call of Duty: Black Ops III	Activision		Y	12
2015	2	Madden NFL 16	Electronic Arts	John Madden, NFL	Y	27
2015	3	Fallout 4	Bethesda		Y	18
2015	4	Star Wars: Battlefront	Electronic Arts	Star Wars	Y	11
2015	5	Grand Theft Auto V	Take Two		Y	18
2015	6	NBA 2K16	2K		Y	16
2015	7	Minecraft	Mojang		N	4
2015	8	FIFA 16	Electronic Arts	FIFA	Y	22
2015	9	Mortal Kombat X	Warner Bros.		Y	23
2015	10	Call of Duty: Advanced Warfare	Activision		Y	12
2016	1	Call of Duty: Infinite Warfare	Activision		Y	13
2016	2	Battlefield 1	Electronic Arts		Y	14
2016	3	Tom Clancy's The Division	Ubisoft	Tom Clancy	N	0
2016	4	NBA 2K17	2K	NBA	Y	17
2016	5	Madden NFL 17	Electronic Arts	John Madden, NFL	Y	28
2016	6	Grand Theft Auto V	Take Two		Y	19
2016	7	Overwatch	Blizzard Entertainment		N	0
2016	8	Call of Duty: Black Ops III	Activision		Y	13
2016	9	FIFA 17	Electronic Arts	FIFA	Y	23
2016	10	Final Fantasy XV	Square Enix		Y	29
2017	1	Call of Duty: WWII	Activision		Y	14
2017	2	Star Wars: Battlefront II	Electronic Arts	Star Wars	Y	13
2017	3	Super Mario Odyssey	Nintendo		Y	32
2017	4	NBA 2K18	2K	NBA	Y	18
2017	5	Mario Kart 8	Nintendo		Y	25
2017	6	Madden NFL 18	Electronic Arts	John Madden, NFL	Y	29
2017	7	PlayerUnknown's Battlegrounds	PUBG		N	0
2017	8	Assassin's Creed: Origins	Ubisoft		Y	10
2017	9	The Legend of Zelda: Breath of the Wild	Nintendo		Y	31
2017	10	Grand Theft Auto V	Take Two		Y	20
2018	1	Red Dead Redemption 2	Take Two		Y	14
2018	2	Call of Duty: Black Ops 4	Activision		Y	15
2018	3	NBA 2K19	2K	NBA	Y	19
2018	4	Madden NFL 19	Electronic Arts	John Madden, NFL	Y	30
2018	5	Super Smash Bros. Ultimate	Nintendo		Y	19
2018	6	Marvel’s Spider-Man	SCE	Spider-Man	N	0
2018	7	Far Cry 5	Ubisoft		Y	14

2018	8	God of War 2018	SCE		Y	13
2018	9	Monster Hunter: World	Capcom		Y	14
2018	10	Assassin's Creed: Odyssey	Ubisoft		Y	11

Table A-3. The list of sales (in millions of units), according to the site *VGChartz*, for the first 20 games in representative video game IP franchises from the publishers in the sample.

Series	Publisher	Sales (in millions) according to VGChartz									
		1	2	3	4	5	6	7	8	9	10
Call of Duty	Activision Blizzard	N/A	2.1	7.5	17.3	15.0	25.0	30.4	30.7	29.6	28.8
Guitar Hero	Activision Blizzard	2.4	7.3	16.4	10.0	4.9	2.6	3.0	-	-	-
Tony Hawk	Activision Blizzard	7.1	6.1	7.5	5.2	5.9	3.6	3.0	2.6	1.6	2.2
Battlefield	EA	N/A	1.4	17.3	14.6	13.1	-	-	-	-	-
Madden NFL	EA	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1.3	1.4	2.6
The Sims	EA	3.7	1.7	13.7	5.5	-	-	-	-	-	-
Tekken	Bandai Namco	3.2	5.7	7.2	3.4	3.9	4.1	1.8	-	-	-
Ace Combat	Bandai Namco	N/A	0.9	0.8	3.2	1.7	1.0	1.2	-	-	-
Dark Souls	Bandai Namco	3.1	3.2	3.1	-	-	-	-	-	-	-
Grand Theft Auto	Take Two	2.3	3.4	13.1	16.2	23.9	22.5	-	-	-	-
NBA 2K	Take Two	N/A	N/A	1.5	1.5	0.8	2.5	1.5	1.8	2.0	2.3
Bioshock	Take Two	4.7	4.0	4.4	-	-	-	-	-	-	-
Tomb Raider	Square Enix	5.7	7.5	4.2	2.9	0.6	1.3	3.1	2.6	1.7	-
Hitman	Square Enix	N/A	4.3	1.1	1.1	4.0	1.0	-	-	-	-
Just Dance	Ubisoft	7.2	9.5	12.8	8.9	6.9	4.7	2.4	8.3	5.3	3.8
Assassin's Creed	Ubisoft	11.3	11.4	7.0	9.2	14.3	13.7	-	-	-	-
Splinter Cell	Ubisoft	5.9	2.8	2.2	1.3	2.2	2.3	-	-	-	-
Batman	Warner Bros. Interactive	8.1	10.8	4.9	5.8	-	-	-	-	-	-
Metal Gear Solid	Konami	6.1	7.2	4.8	6.0	4.1	-	-	-	-	-
Silent Hill	Konami	1.6	1.6	0.7	0.7	0.8	-	-	-	-	-
		11	12	13	14	15	16	17	18	19	20
Call of Duty	Activision Blizzard	21.8	26.6	13.4	19.1	-	-	-	-	-	-
Guitar Hero	Activision Blizzard	-	-	-	-	-	-	-	-	-	-
Tony Hawk	Activision Blizzard	1.1	0.5	-	-	-	-	-	-	-	-
Battlefield	EA	-	-	-	-	-	-	-	-	-	-
Madden NFL	EA	2.4	3.8	6.4	5.9	7.1	7.6	9.0	10.0	8.1	8.0
The Sims	EA	-	-	-	-	-	-	-	-	-	-
Tekken	Bandai Namco	-	-	-	-	-	-	-	-	-	-
Ace Combat	Bandai Namco	-	-	-	-	-	-	-	-	-	-
Dark Souls	Bandai Namco	-	-	-	-	-	-	-	-	-	-
Grand Theft	Take Two	-	-	-	-	-	-	-	-	-	-

Auto											
NBA 2K	Take Two	3.0	5.5	5.6	6.3	7.3	7.3	8.3	6.3	5.7	-
Bioshock	Take Two	-	-	-	-	-	-	-	-	-	-
Tomb Raider	Square Enix	-	-	-	-	-	-	-	-	-	-
Hitman	Square Enix	-	-	-	-	-	-	-	-	-	-
Just Dance	Ubisoft	-	-	-	-	-	-	-	-	-	-
Assassin's Creed	Ubisoft	-	-	-	-	-	-	-	-	-	-
Splinter Cell	Ubisoft	-	-	-	-	-	-	-	-	-	-
Batman	Warner Bros. Interactive	-	-	-	-	-	-	-	-	-	-
Metal Gear Solid	Konami	-	-	-	-	-	-	-	-	-	-
Silent Hill	Konami	-	-	-	-	-	-	-	-	-	-

Table A-4. The list of ratings (out of 100%), according to the site *Metacritic*, for the first 20 games in representative video game IP franchises from the publishers in the sample.

Series	Publisher	Metacritic rating (out of 100%)									
		1	2	3	4	5	6	7	8	9	10
Call of Duty	Activision Blizzard	91	89	83	94	85	94	83	88	83	78
Guitar Hero	Activision Blizzard	91	92	86	86	89	77	84	-	-	-
Tony Hawk	Activision Blizzard	92	98	97	94	90	85	77	81	79	47
Battlefield	EA	N/A	91	89	85	89	-	-	-	-	-
Madden NFL	EA	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
The Sims	EA	92	90	86	70	-	-	-	-	-	-
Tekken	Bandai Namco	N/A	N/A	N/A	79	88	82	82	-	-	-
Ace Combat	Bandai Namco	N/A	N/A	N/A	89	84	80	78	-	-	-
Dark Souls	Bandai Namco	89	91	89	-	-	-	-	-	-	-
Grand Theft Auto	Take Two	N/A	70	97	95	95	98	97	-	-	-
NBA 2K	Take Two	N/A	93	93	89	89	85	84	84	81	84
Bioshock	Take Two	96	88	94	-	-	-	-	-	-	-
Tomb Raider	Square Enix	91	85	76	N/A	63	52	82	80	87	88
Hitman	Square Enix	73	87	80	83	83	85	-	-	-	-
Just Dance	Ubisoft	49	74	75	77	79	75	73	73	75	-
Assassin's Creed	Ubisoft	81	91	90	80	85	88	74	72	78	85
Splinter Cell	Ubisoft	93	93	94	89	85	84	-	-	-	-
Batman	Warner Bros. Interactive	92	96	76	87	-	-	-	-	-	-
Metal Gear Solid	Konami	94	96	91	94	95	-	-	-	-	-
Silent Hill	Konami	86	89	85	76	71	79	68	-	-	-
		11	12	13	14	15	16	17	18	19	20
Call of Duty	Activision Blizzard	83	81	78	80	-	-	-	-	-	-
Guitar Hero	Activision Blizzard	-	-	-	-	-	-	-	-	-	-
Tony Hawk	Activision Blizzard	56	39	-	-	-	-	-	-	-	-
Battlefield	EA	-	-	-	-	-	-	-	-	-	-
Madden NFL	EA	N/A	91	94	95	94	91	88	84	85	85
The Sims	EA	-	-	-	-	-	-	-	-	-	-
Tekken	Bandai Namco	-	-	-	-	-	-	-	-	-	-
Ace Combat	Bandai Namco	-	-	-	-	-	-	-	-	-	-
Dark Souls	Bandai Namco	-	-	-	-	-	-	-	-	-	-
Grand Theft Auto	Take Two	-	-	-	-	-	-	-	-	-	-

NBA 2K	Take Two	85	89	90	90	87	87	87	90	87	-
Bioshock	Take Two	-	-	-	-	-	-	-	-	-	-
Tomb Raider	Square Enix	-	-	-	-	-	-	-	-	-	-
Hitman	Square Enix	-	-	-	-	-	-	-	-	-	-
Just Dance	Ubisoft	-	-	-	-	-	-	-	-	-	-
Assassin's Creed	Ubisoft	-	-	-	-	-	-	-	-	-	-
Splinter Cell	Ubisoft	-	-	-	-	-	-	-	-	-	-
Batman	Warner Bros. Interactive	-	-	-	-	-	-	-	-	-	-
Metal Gear Solid	Konami	-	-	-	-	-	-	-	-	-	-
Silent Hill	Konami	-	-	-	-	-	-	-	-	-	-

Appendix B. Tools and Software Used

Microsoft Excel

- Used for storing aggregated data and for simple statistical calculations and visualizations

https://products.office.com/en/excel

Adobe Photoshop

- Used for scaling the staff role visualizations (bicubic resampling)

https://www.adobe.com/products/photoshop.html

POWERGrep

- Used for advanced file searching and replacing

https://www.powergrep.com/

Python 2.7

- Used to write webcrawlers with which data was gathered

https://www.python.org/download/releases/2.7/

R: The R Project for Statistical Computing

- Used for the majority of statistical calculations and visualizations

https://www.r-project.org/

R Studio

- Used as the graphical user interface for R

https://www.rstudio.com/

Additional R Libraries

boot library

- Used for bootstrapping tests
  Authors: Angelo Canty [aut], Brian Ripley [aut, trl, cre] (author of parallel support)
  https://cran.r-project.org/web/packages/boot/index.html

tree library

- Used for the regression tree functionality
  Authors: Brian Ripley [aut, cre]
  https://cran.r-project.org/web/packages/tree/index.html

car library

- Used for the NCV test / Breusch-Pagan test
  Authors: John Fox [aut, cre], Sanford Weisberg [aut], Daniel Adler [ctb], Douglas Bates [ctb], Gabriel Baud-Bovy [ctb], Steve Ellison [ctb], David Firth [ctb], Michael Friendly [ctb], Gregor Gorjanc [ctb], Spencer Graves [ctb], Richard Heiberger [ctb], Rafael Laboissiere [ctb], Georges Monette [ctb], Duncan Murdoch [ctb], Henric Nilsson [ctb], Derek Ogle [ctb], Brian Ripley [ctb], William Venables [ctb], David Winsemius [ctb], Achim Zeileis [ctb], R-Core [ctb]
  https://cran.r-project.org/web/packages/car/index.html

Hmisc library

- Used for correlations
  Authors: Frank E Harrell Jr, with contributions from Charles Dupont and many others.
  https://cran.r-project.org/web/packages/Hmisc/index.html

ggplot2 library

- Used for enhanced visualizations
  Authors: Hadley Wickham [aut, cre], Winston Chang [aut], RStudio [cph]
  https://cran.r-project.org/web/packages/ggplot2/index.html

moments library

- Used for evaluating skew and kurtosis
  Authors: Lukasz Komsta, Frederick Novomestky
  https://cran.r-project.org/web/packages/moments/index.html