

# KNOWLEDGE ECONOMIES AND KNOWLEDGE WORK

# WORKING METHODS FOR KNOWLEDGE MANAGEMENT

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# KNOWLEDGE ECONOMIES AND KNOWLEDGE WORK

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# INTRODUCTION TO THE SERIES – WORKING METHODS IN KNOWLEDGE MANAGEMENT

Knowledge sciences as a discipline has a rich and diverse history dating back to the 1950s. In the past 70 years, the discipline has drawn theory and practice from economics, engineering, communications, learning sciences, technology, information sciences, psychology, social sciences, and business and organization management. To craft this discipline, we have developed our own language and terminologies, established our own peer reviewed journals and built a rich research foundation, created a gray literature, and established a series of networks and conferences. Over the decades there have been many knowledge management education programs, but there has been no consistent curriculum and few have sustained. It has been challenging for new practitioners to gain an understanding of the field. And, while the practice of knowledge management is growing around the world it has not yet achieved the expected organizational stature. For knowledge management to rise to the stature of other business functions and operations, it must be able to speak the language of business, align with, and support the way the organization works.

This series is designed for business and knowledge management practitioners. *Working Methods in Knowledge Management* is a multi-year and multi-volume series designed to address each and all of the methods required to establish and sustain an organization-wide knowledge management function. The goal of the series is to provide a business perspective of each topic. Each book begins by grounding the method in the business context – then translates established business models and methods to a knowledge management context. It is often the case that this translation expands and extends the business model and method.

The knowledge management literature is rich with introductory handbooks, guidebooks, cookbooks, toolkits, and practical introductions. This literature is an important starting point for anyone new to the discipline. We recommend any and all of these books as a way to build a fundamental understanding of the scope and coverage of the field. These texts will provide a good 10–20 page introduction to all of the key issues you need to be aware of as you embark on a new career in the field or have been assigned a new knowledge management role or responsibility. Once you have that grounding, though, we recommend that you look to the *Working Methods in Knowledge Management* texts as an intermediate source for understanding “What comes next? What now?”

Just as this series is not intended as a starting point for the field, neither is it an ending point. Each text is designed to support practical application, and to foster a broader discussion of practice. It is through practical application and extended discussion that we will advance theory and research. The editors anticipate that as practice expands, there will be a need to update the texts – based on what we are learning. Furthermore, the editors hope that the texts are written in a way that allows business managers to extend their work to



include knowledge management functions and assets. We will learn most from expanding the discussion beyond our core community.

## JOINT ENTERPRISE, MUTUAL ENGAGEMENT, AND A SHARED REPERTOIRE

From the outset, the publisher and the editors have established a new and different approach to designing and writing the books. Each text is supported by a team of authors who represent multiple and diverse views of the topic. Each team includes academics, practitioners, and thought leaders. Every author has grappled with the topic in a real world context. Every author sees the topic differently today than they did when the project began. Over the course of several months, through weekly virtual discussions, the scope and coverage were defined. Through mutual engagement and open sharing, each team developed a joint enterprise and commitment to the topic that is enduring. Every author learned through the discussion and writing process. Each project has resulted in a new shared repertoire. We practiced knowledge management to write about knowledge management. We “ate our own dog food.”

## ACKNOWLEDGEMENTS OF EARLY SUPPORT

The series is a massive effort. If there is value in the series much of the credit must go to two individuals – Dr Elias Carayannis, George Washington University, and Dr Manlio Del Giudice, University of Rome. It was Dr Carayannis who first encouraged us to develop a proposal for Emerald Publishers. Of course, this encouragement was just the most

recent form of support from Dr Carayannis. He has been a mentor and coach for close to 20 years. It was Dr Carayannis who first taught me the importance of aligning knowledge management with business administration and organizational management. Dr Del Giudice has been generous with his guidance – particularly in setting a high standard for any and all knowledge management research and practice. We are grateful to him for his careful review and critique of our initial proposal. His patience and thoughtful coaching of colleagues is rare in any field. The field will reach its full potential as long as we have teachers and editors like Dr Del Giudice.

# PREFACE

## OVERVIEW OF THE SUBJECT MATTER

The economy is continually evolving. Over the past 70 years the US economy has been shifting from an advanced industrial to a knowledge-based economy. This shift was first observed by Machlup in the 1950s, and has been further chronicled and characterized by other leading economists and researchers. Since the 1950s economists have attributed the shift to the rise in importance of services, information, an increasingly educated and trained workforce, technology, an increasingly virtual work environment, and increases in artificial intelligence and automation. The common element to all of these perspectives is the increased value of knowledge. In the twenty-first century, knowledge is now a primary factor of production. It is equivalent to financial and physical capital in the industrial economy and to land and physical labor in the agricultural economy. The shifting economy is changing the external business environment in which organizations function, and the internal business environment that enables them to survive. The external environment includes other organizations, as well as the cities and neighborhoods in which they function. It is important for organizations to understand the extent of the changes and impacts, particularly as they affect the workforce. And, it is important for all of us in the workforce to see these changes as opportunities, and

to better understand how we can leverage our individual and collective knowledge capital to succeed in this new economy.

The shifting economy also has affected the nature of work. Labor economists, sociologists, and human resource researchers have chronicled the shift in work – from physical labor to knowledge work, from labor that supports a predefined business process to one that leverages capabilities. Knowledge work has been characterized as work that requires educational credentials and leverages “thinking.” This characterization is further reinforced by the increased automation of processed based work, off-shoring of jobs, and the increased number of jobs that required advanced qualifications. Every day we read of neighborhoods and cities that have been devastated by the loss of jobs and the impact this loss has on everyday lives. It is important for workers to understand the changes as they affect work. There is a massive amount of publicly available data about the future of work in the knowledge economy. Organizations and individuals can leverage this data for developing near- and long-term visions and strategies. While data and information are important, though, it is the individual and collective knowledge capital of individuals, neighborhoods, groups, organizations, and cities that will define what we mean by work in the future.

Parallel to evolving research on the knowledge economy is the emergence of a new field of study – knowledge management and knowledge sciences. This field has evolved through several stages, first focusing on encoded information, then on systems, to people-related exchanges and learning, to today’s knowledge analytics. Our description of the evolution of the field suggests a focus on tactics rather than on visions and big pictures.

There is an opportunity – and a need – to align these three views. This book explains the knowledge economy as a shift to knowledge capital. It explains knowledge work

as the leveraging of knowledge capital in any context. It explains that managing knowledge capital means shifting our perspective from people as “human resources” linked to a process to one that views people as sources of knowledge capital and organizational capacity. Most importantly, though, the book argues that the true focus of knowledge management should be on helping organizations and individuals to navigate the changes – by focusing on planning for the future.

There is a need for practical guidance on how to navigate the changes today and in the future. This book takes a project focused approach to building an understanding of the future and its likely impact on organizations and individuals. Authors represent the three perspectives.

## WHERE THE TOPIC FITS IN THE WORLD TODAY

The topic of the knowledge economy and knowledge work is at the center of our public discourse today. The shifting economic landscape and the changing nature and structure of work have been attributed to many different factors – some of them causal and some of them symptomatic. This book speaks to a key factor – both causal and symptomatic – of the change – the role of knowledge capital. Knowledge capital is an emerging source of wealth and a new primary factor of production. Those organizations and individuals who understand what it is, how it behaves, its challenges and opportunities will thrive and survive in the knowledge economy. Those organizations and individuals who fail to recognize this new capital may find it difficult to succeed.

While the factors and symptoms are all well-known and easily recognized, the topic needs further attention and discussion. The discussion needs to expand beyond the academic

world to the practical everyday working world. The discussion needs to expand beyond the technology community, the highly credentialed and the upper income classes to all sectors and all levels of our society. The broader the discussion and understanding, the more people will be engaged in shaping what the knowledge economy and knowledge work of the future looks like.

## WHERE THE BOOK FITS IN THE LITERATURE TODAY

This is the first book in the new series. This book sets a context for the methods that are addressed in the series. This book describes the shifting economic landscape and explains why we need to adapt existing methods and in some cases why we need new methods to navigate the changing economic landscape.

The knowledge management literature is rich and varied. Over the past 70 years this literature has drawn from the fields of management, economics, learning and education, social interactions, discourse and information science, cultural studies, artificial intelligence, and engineering and technology. Knowledge management has drawn and synthesized theory from all these fields, but it has primarily focused on tactics. In the early twenty-first century, knowledge management is primarily an applied field. This book helps the reader and the practitioner translate tactics to the bigger picture – why we need to do knowledge management – and provides a context for evaluating whether our tactics are up to the challenge of this new environment.

The authors intend the book to fill a gap in the management literature – to present the economic changes underway not from a “post” or “advanced industrial” economy but as a

new kind of economy. Businesses and organizations can navigate the complex and dynamic shifts if they understand the underlying factors and causes. This book attempts to describe this new economy.

While there is a rich economics literature focused on the knowledge economy, little of it focuses on knowledge capital. The majority of this literature focuses on technology, education, business, and innovation – important aspects of the new economy – but symptoms rather than causal factors. This book introduces an in depth discussion of knowledge capital and sets a context for the methods individuals and organizations will use to manage and leverage knowledge capital.

The changing economic landscape also shifts who participates in research and learning. Finally, this book attempts to connect the gray literature, conference literature, and practitioner experience to emerging theory.

## DESCRIPTION OF THE TARGET AUDIENCE

This text is written for business managers who are experiencing and need to understand the factors that are causing the changing economic landscape. The book is written for organizational executives who need to begin transitioning what they manage and how they manage their organizations from an industrial to a knowledge perspective. The book is written for human resource managers whose future role in knowledge organizations will either be pivotal or non-existent depending on how they navigate that future. The book is written for knowledge management professionals and practitioners who need to focus on the future and to connect their tactics and activities to the bigger picture. Finally, the book is written for labor studies professionals, labor economists, and sociologists

who need to help us navigate the shift from “labor” and “jobs” to knowledge capital and its sources – people.

## STRUCTURE OF THE BOOK

The book is organized into four sections and seventeen chapters. Section 1 focuses on explaining the forces behind the economic changes, the knowledge economy, the increasing role of knowledge as organizational capital, and the effects these changes are having on our everyday world. Section 2 focuses on knowledge capital specifically human capital, structural capital, and relational capital. This section provides examples of and explains the behavior of each kind of knowledge capital. Section 3 explores how these changes are reshaping our basic definitions and characterization of work. When work changes, all of those functions that are devoted to managing work also change – including management functions, human resource management functions, and learning and training. Section 4 focuses on stories that illustrate what the future looks like when organizations and individuals understand and manage the change. These stories are drawn from the authors’ experience over several decades. Each story is described in a common framework. The stories have been written to highlight the key issues. The story details are not representative of any one location, organization, or individual.

Each chapter is written like a project description. While the authors can explain the knowledge economy, knowledge work, and knowledge capital, we cannot tell you what this means for you or your organization. Only an organization can interpret the change. Each chapter provides background information on the topic as well as references to additional resources – both theory and practice. Each chapter highlights the thought leaders and practitioners in that topic.



## Section 1. Knowledge Economy

Chapter 1. How the Economic Landscape is Changing

Chapter 2. How the Knowledge Economy Works

Chapter 3. The Knowledge Economy: Implications for  
Organizations, Work and Workers

Chapter 4. Knowledge Economy Fundamentals

## Section 2. Building the New Knowledge Capital

Chapter 5. Knowledge Capital – The Big Picture

Chapter 6. Human Capital – Definitions and Growth

Chapter 7. Structural Capital – Definitions and Growth

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## Section 3. How the Knowledge Economy Affects Organizations and Individuals

Chapter 9. How Work Changes in the Knowledge  
Economy

Chapter 10. How Management Changes

Chapter 11. How Human Resource Management Changes  
in the Knowledge Economy

Chapter 12. Learning and the Knowledge Capacity of  
Organizations

## Section 4. Stories of Place in a Knowledge Economy

Chapter 13. Role of Place in Growing and Leveraging  
Knowledge Capital

Chapter 14. Business Stories of Knowledge Capital

## CHAPTER SUMMARIES

Chapter 1 sets the context by explaining how the economic landscape is changing. The chapter describes the transformation that has been underway over the past 70 years. The chapter describes the implications of the transformation for the way work is done, for changes to the rate and nature of employment, the skills required of workers, and the meaning and measurement of capital. The chapter also describes the difference and relationships between knowledge and information. Finally, the chapter presents an argument for treating knowledge as capital comparable to financial and physical assets.

Chapter 2 provides a high-level explanation of how the knowledge economy works and how it is different from earlier economies. The knowledge economy transformation introduced in Chapter 1 is only the latest of several economic transformations that have occurred over the centuries. The agricultural economy gave way to the industrial economy, which gave way to the knowledge economy. This chapter explores the first two of these transformations. Understanding how those economies developed, and the support structures that allowed them to function, helps to put the knowledge economy transformation in context. This discussion is intended to provide insight into how the knowledge transformation has occurred, which is the focus of Chapter 3.

Chapter 3 provides a deep dive into the organization's current capital management practices. This chapter establishes a foundation for comparison of current and future capital sources – by helping the reader to see how their organization currently manages physical and financial capital. And, by exposing how the organization currently defines and manages knowledge. This chapter concludes with general observations about how the view of knowledge as capital may need to change.

Chapter 4 considers the essential nature of a knowledge economy – knowledge. The authors describe knowledge as a capital commodity and describe its economic properties. The chapter begins with a discussion of the economic properties of knowledge that cause knowledge transactions and knowledge markets to behave differently than commodity or financial markets. This chapter considers how those economic properties change the behavior of a knowledge economy. The chapter explains how a knowledge economy relates to other new age economies including the information economy, the service economy, the high-tech economy, the networked economy, the sharing economy, and the precariat or gig economy. This chapter addresses what economists typically refer to as the “So what” questions – how are these changes affecting the average person, the average community, the typical organization, or a typical city? The chapter also lays out some critical questions of how these changes are likely to continue to shift our world – how it changes roles and responsibilities.

Chapter 5 provides an overview of knowledge capital. The chapter explains what knowledge capital is and why it has value, and how it is like/unlike other types of capital. The chapter defines and describes the three categories of knowledge capital including human capital, structural capital, and relational capital. The authors provide a breakdown of human capital, structural capital, and relational capital, and explain how and why each type is important to the organization and to individuals.

Chapter 6 offers a deep dive into human capital. Human capital defines the knowledge assets of individuals. The chapter builds on the definitions and descriptions of human capital assets offered in Chapter 5. The chapter breaks human capital down into tacit knowledge, skills and competencies, and attitudes and behaviors. Practical examples are offered to help translate the economic concepts. The chapter concludes

by encouraging the reader to consider how these new forms of capital are currently being managed.

Chapter 7 offers a deep dive into structural capital. Structural capital defines the aggregate and collective knowledge assets of communities and organizations. The chapter builds on the definitions and descriptions of structural capital offered in Chapter 5. The chapter breaks structural capital down into explicit information resources, procedural knowledge, and organizational culture. Practical examples are offered to help interpret the economic concepts. The chapter concludes by encouraging the reader to consider how these new forms of capital are currently being managed.

Chapter 8 offers a deep dive into relational and network capital. Relational capital defines the knowledge assets of networks not necessarily constrained to organizations or communities. Relational capital also considers how knowledge flows across nodes in the network. It also includes reputational capital – the factors that contribute to whether a source or target is trusted and how it may be valued. Relational and reputational capital are often treated as hidden value or assets – this chapter explores how to translate these assets for tangible management.

Chapter 9 shifts the focus to work and considers how the shifting economy is changing the nature of work. The chapter describes how we have traditionally characterized work in the industrial economy – as supporting a defined business process, with predefined job classes and streams, and job descriptions. The chapter considers how this characterization of work has affected the people who work for the organization including how they develop their knowledge capital to suit existing work opportunities. The chapter considers how the knowledge economy is shifting our definition of work – from process support to organizational and individual capabilities. The chapter also considers how the culture of work is changing.

Chapter 10 considers how these changes are affecting our management functions. The chapter explores changes in who manages, what they manage and how they manage. Will the knowledge economy change our traditional management roles and responsibilities? Will it shift the basic management functions of direction, command, control to coaching, mentoring, personnel growth and development, and sponsorship? Will the changes mean that every individual has some degree of management responsibility? Will who manages who change? This chapter also considers changes underway in our management cultures, and the affect these changes are having across generations.

Chapter 11 discusses current and future changes to the human resource management function. The shift in focus from people as business process support resource to primary sources of knowledge capital will affect every aspect of human resource management. The chapter describes the current human resources view of the future – as increasingly focused on and supported by technology – and argues for expanding that view to include knowledge capital. Rather than managing jobs, job classes, and performance evaluation – human resources professionals will shift to developing and investing in people. This chapter projects forward to consider what “people management” might look like in 2025, in 2035, and in 2050.

Chapter 12 explores the implications for learning and training. Learning is the fuel that fuels the growth of knowledge capital. The chapter explains how our understanding of sources and methods of learning is expanded today and how it might change in the future. How we learn and grow all types of knowledge capital is more extensive than simply acquiring a formal education or credentials. The chapter considers what a rich learning environment looks like, and how lifewide and lifelong learning become the new normal. The chapter also considers the new learning cultures.

Chapter 13 explores the impact that knowledge capital has on place, and the impact that place can have on knowledge capital. Place has always been an important factor in economics – in terms of economic concentration, agglomeration economies, economies of scale and scope. Economic concentration has been the motivating force behind the formation of towns and cities. In industrial economies, place was a consideration in where to locate factories, where to locate retail spaces, in the location and concentration of a skilled labor force or an economically advantaged consumer base. Place was a factor in cost models – transportation costs, convenience to natural or specialized resources. Place has impacted the opportunities that individuals have to growing their knowledge capacity. There are new economic subdisciplines that study the economies of geography, the economics of opportunity, and a new subdiscipline of geography that focuses on the geography of work and jobs. In the knowledge economy place has a direct relationship to knowledge capacity building. This chapter considers the challenges and opportunities of place. The authors also speculate on the changing definition of place in the knowledge economy.

Chapter 14 illustrates how different types of knowledge capital can be leveraged to meet challenges which were created by the industrial economy and barriers to traditional forms of capital. The stories describe how knowledge capital is inherent in any individual, grows through interaction and circulation, and is a sustainable source of economic and financial development. The chapter includes 12 stories from a variety of places including urban, suburban, and rural. The stories are derived from different regions of the country and represent different business models. Each story is a version of the truth in that it represents a real-world example but does not reference an individual, a business, or a location directly. It is the authors' intent to demonstrate that the knowledge

economy is impacting all of us. Each of the stories explains how the knowledge economy integrates with the traditional industrial and agricultural economies and creates opportunities where only challenges existed.

## HOW THE BOOK IMPACTS THE FIELD

The authors hope the book will increase awareness and understanding of the shifting economic landscape and its effect on work. Ideally, the book will provide a foundation for an expanded discussion across domains, sectors, and geographical areas to ensure we all have an opportunity to shape the knowledge economy of the future. The book also aims to move the discussion of knowledge capital beyond the intellectual capital management area to the broader public. Finally, we hope the book will change the common perception of “knowledge work” as high skilled or high paid and recognize that every type of work leverages knowledge and is therefore knowledge work.

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## SECTION 1

### KNOWLEDGE ECONOMY

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# 1

## HOW THE ECONOMIC LANDSCAPE IS CHANGING

### CHAPTER SUMMARY

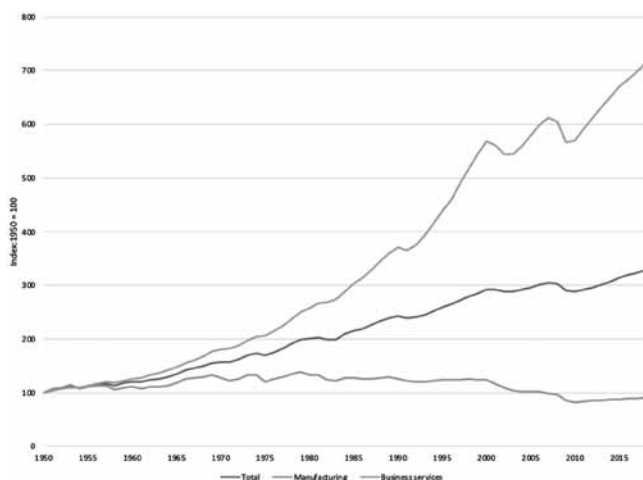
This chapter sets the context by explaining how the economic landscape is changing. The chapter describes the transformation that has been underway over the past 70 years. The chapter describes the implications of the transformation for the way work is done, for changes to the rate and nature of employment, the skills required of workers, and the meaning and measurement of capital. The chapter also describes the difference and relationships between knowledge and information. Finally, the chapter presents an argument for treating knowledge as capital comparable to financial and physical assets.

### THE KNOWLEDGE ECONOMY TRANSFORMATION

Over the past several decades, economies in the United States and across the developed world have increasingly become knowledge-driven. [Powell and Snellman \(2004\)](#) define the knowledge economy as “production and services based on

knowledge-intensive activities that contribute to an accelerated pace of technical and scientific advance” (p. 199). The emphasis in a knowledge economy is on knowledge and skill-based inputs and outputs rather than physical inputs and outputs. As is discussed in Chapter 2, however, this transformation is only the most recent in a series of economic reorganizations over the centuries.

The transformation to a knowledge economy has substantial implications for the way work is done, the employment growth of individual industry sectors, the skills required of workers, and the meaning and measurement of capital. The transformation’s impact on employment is shown in Fig. 1. This chart compares national employment growth since 1950 of manufacturing, the key production sector, professional and business services, a major knowledge-producing sector, and



**Fig. 1. The Shift from Manufacturing Employment to Professional and Business Services Employment in the United States, 1950–2017.**

Source: [United States Bureau of Labor Statistics \(2019\)](#).

total employment. Both employment totals are set equal to 100 in 1950, and cumulative percentage employment changes since then are charted.

In 1950, manufacturing employed 14 million workers, nearly one-third of total employment. The 2.9 million workers in professional and business services, meanwhile, comprised 6.5% of employment. Beginning in the late 1950s, manufacturing employment growth began to trail total employment growth. A secular decline in employment began in the early 1980s; manufacturing employment peaked in 1979 at 19.4 million. By 2018, manufacturing employed 12.7 million workers, 8.5% of total employment and a smaller job total than in 1950.

In contrast, professional and business services' employment growth accelerated in the late 1950s, at the same time as manufacturing employment growth began to lag. The sector's rise has suffered only two noteworthy setbacks: the first due to the dot-com bust of the early 2000s and the second driven by the severe 2007–2009 recession. Despite these two relatively brief declines, professional and business services employment has increased more than sevenfold since 1950 and stood at 21 million in 2018, 14% of total US employment.

There is a danger in these discussions of falling into the trap of defining knowledge in terms solely of high-skill occupations, such as attorneys, scientists, economists, and college professors. In fact, the knowledge economy extends to virtually all industries and occupations. It includes the ability of a factory worker to program and operate a computer numerical control machine, a hairdresser to give a client a permanent, a plumber to find and correct a leak, and a salesperson to provide excellent customer service. In every case, the application of knowledge has created value for the organization. This perspective of knowledge jobs as necessarily high-skill arises from the implicit devaluing of so-called “middle-skill

jobs” and emphasis on four-year degrees as the only path to professional and financial success. This has led to a severe shortage of skilled-trade workers as older workers retire. Compounding this problem is the fact that the US Census Bureau, unlike comparable agencies in Europe, tracks educational attainment solely on the basis of diplomas and degrees, not licenses and certifications. There is no centralized source for the number of these credentials.

Consider the impact of knowledge on the manufacturing sector, as shown in Fig. 2. This chart graphs the trends in employment and inflation-adjusted gross domestic product (GDP) of manufacturing between 1997 and 2007. GDP is not the total value of manufactured products; rather, it is the value added during the manufacturing process. The final price of fabricated steel products, for example, includes not only the manufacturing inputs, but also the inputs of mining,



**Fig. 2. The Relationship between Manufacturing Employment and GDP, 1997–2007.**

Source: [United States Bureau of Labor Statistics \(2019\)](#) and [United States Bureau of Economic Analysis \(2019\)](#).

transportation, wholesaling, and possibly retailing as well. In contrast, GDP isolates the activities of manufacturers.

The period charted begins late in the boom of the 1990s, continues through the relatively mild 2001 recession, the expansion of 2001–2007, the severe recession of 2007–2009, and ends during the expansion that began in 2009. The period from 1997 to 2010 was one of stagnant then sharply declining manufacturing employment. This trend caused considerable consternation in the popular press and among the political class. The argument was that based upon the employment declines, American manufacturing was dying and being exported in its entirety overseas. But the increase in the marginal value of US manufacturing output reveals the fallacy of this argument. Simultaneously with a 20% decline in manufacturing employment, there was a 45% increase in the value of US manufacturers' production. Productivity of manufacturing workers – defined as the value of output per worker – increased 81%.<sup>1</sup> This trend continued through the recession even as output fell. Between 2007 and 2009, employment declined 15% as GDP fell 11%, yielding a productivity increase of 4%. Jobs were not being exported overseas; rather, they were disappearing altogether as technology and robotics took on tasks formerly performed by workers.<sup>2</sup>

This relationship has been less clear-cut after the recession. Beginning in 2010, manufacturing employment began to grow – its first sustained employment increase since the 1960s. Employment increased 7% between 2010 and 2018 as GDP increased 16%, yielding a net productivity increase of only 9%. This represents an annual growth rate of 0.9%, less than one-sixth the rate between 1997 and 2007.

The time trend of productivity is charted in [Fig. 3](#), which shows a clear break in 2010. In contrast to the steady growth in earlier years, the trend after 2010 has been erratic.



**Fig. 3. Manufacturing GDP per Worker, 1997–2018.**

Source: [United States Bureau of Labor Statistics \(2019\)](#) and [United States Bureau of Economic Analysis \(2019\)](#).

Productivity suffered declines in 2011, 2012, and 2014–2017. In fact, the only reason that there was a net increase in productivity between 2010 and 2018 was a 2.4% gain in the final year.

This shift to technology in manufacturing has led to a substantial change in the knowledge demands placed upon manufacturing workers. As these workers interact with the technology, they need to understand how the technology works and how to remedy the situation if a problem occurs. The shifting environment within manufacturing operations has led to additional skill demands as well. The Chief Executive Officer of a manufacturing plant in southeastern Ohio told one of the authors that he expects all of his new hires to have leadership ability, or at least the potential to develop it. Manufacturing in that plant, and in many other plants, occurs in a team environment, and those teams need leaders.

Knowledge has impacted the manufacturing process in a variety of ways. Engineers develop an understanding of the