

ROUTLEDGE FOCUS

INDUSTRY EMERGENCE

Strategic Management and Synchronization
for New Industries

Gregory Theyel

ROUTLEDGE
Focus

Industry Emergence

Strategic Management and
Synchronization for New Industries

Gregory Theyel

First published 2017
by Routledge
711 Third Avenue, New York, NY 10017

and by Routledge
2 Park Square, Milton Park, Abingdon, Oxon OX14 4RN

Routledge is an imprint of the Taylor & Francis Group, an informa business

© 2017 Taylor & Francis

The right of Gregory Theyel to be identified as author of this work has been asserted by him in accordance with sections 77 and 78 of the Copyright, Designs and Patents Act 1988.

All rights reserved. No part of this book may be reprinted or reproduced or utilised in any form or by any electronic, mechanical, or other means, now known or hereafter invented, including photocopying and recording, or in any information storage or retrieval system, without permission in writing from the publishers.

Trademark notice: Product or corporate names may be trademarks or registered trademarks, and are used only for identification and explanation without intent to infringe.

Library of Congress Cataloging-in-Publication Data
A catalog record for this book has been requested

ISBN: 978-0-415-73499-8 (hbk)
ISBN: 978-1-315-81948-8 (ebk)

Typeset in Times New Roman
by codeMantra

Industry Emergence

This book develops a novel industry emergence framework to explain the features, interaction, and synchronization of key elements for the birth and growth of new industries.

Organized around seven elements—firm strategy, technology, investment, supply networks, production, markets, and government—Theyel's framework provides inventors, managers, investors, scholars, and policy-makers with a comprehensive understanding of how industries emerge, helping them to be more successful at influencing the birth and growth of new industries. Understanding industry emergence is important because new industries can offer the advancement of technology, improvements in human health and the environment, growth of firms, creation of jobs, and economic development.

With learning objectives, theories, tools, case studies, and end-of-chapter exercises, *Industry Emergence* will be a useful resource for students and professionals in engineering, science, business, and policy.

Gregory Theyel is a Professor at California State University, USA. He is also president of Green Visions, which assists companies with technology commercialization, and governments with the growth of new industries and economic development.

List of Figures

1.1	Framework for Understanding Industry Emergence	5
2.1	Firm Strategy and Industry Emergence	13
2.2	UAV-Related Publications	14
3.1	Technology and Industry Emergence	24
3.2	Growth of Wearable Technology	26
3.3	Technology and Regenerative Medicine Industry Emergence	29
4.1	Investment and Industry Emergence	33
5.1	Supply Networks and Industry Emergence	45
5.2	Li-Ion Pricing and Energy Density	48
5.3	Global Wind Power Capacity	50
6.1	Production and Industry Emergence	54
7.1	Markets and Industry Emergence	64
7.2	Global Solar PV Electricity Generation	70
8.1	Government and Industry Emergence	75
8.2	Virtual Reality Patents	79
8.3	Global Biotechnology Sales Growth	81
9.1	Number of Firms (Percentage Growth)	87
9.2	Technology – Patenting (Percentage Growth)	88
9.3	Investment (Percentage Growth)	89
9.4	Supply Networks (Price Change of Inputs)	90
9.5	Production (Scale)	91
9.6	Markets (Percentage Growth)	91
9.7	Government (Spending)	92
9.8	Interaction of Elements for Synchronization	93

Preface

Industry emergence is the birth and early growth of new industries shaped by the interaction and synchronization of the strategic behavior of firms, technological innovation, investment, supply networks, production, markets, and the influence of government and other institutions. We use this description to guide our development of a framework and our understanding of the elements that drive the growth of new industries.

Emerging industries are groups of companies developing around a new, often disruptive idea, technology, product, or service. The purpose of this book is to provide inventors, firms, investors, scholars, and policymakers with understanding about how industries emerge and enable them to be more successful at influencing the birth and growth of new industries. Inventors and firms can benefit from a better understanding of the multiple elements influencing the progress of their technology and business. Investors can make better-informed decisions about their funding of companies. Scholars can present their research in a more systemic context, and policymakers can coordinate their efforts in concert with technology, markets, investment, and firm strategy. Understanding industry emergence is important because new industries can offer the advancement of technology, improvements in human health and the environment, growth of firms, creation of jobs, and economic development.

The unit of analysis for this book is the industry. This book is not specifically about emerging technologies, firms, markets, or countries. While all of these topics are related to emerging industries, this book's contribution is a better understanding of how industries emerge.

The book is organized around seven elements—firm strategy, technology, investment, supply networks, production, markets, and government. The order of the elements is not meant to imply an order of importance. Instead, different elements are more or less important depending on the characteristics of specific emerging industries. This is made clear through the many emerging industry case studies presented throughout the book.

Chapter 1 describes emerging industries, presents a framework of elements for explaining industry emergence, and introduces the concepts of synchronization and states of industry emergence. Synchronization is the coordination of multiple elements so that they reach a particular state simultaneously and is the key concept for industry emergence because important elements need to be synchronized in order for an industry to emerge.

Chapter 2 presents firm strategy, which is how a firm positions itself in an industry and how it uses resources to support its position. An industry consists of (many) firms and the strategic decisions of individual entrepreneurs/firms usually start the process of industry emergence.

Chapter 3 shows that technology, which is made up of design aspects, knowledge, and usually physical components, is often the seed for industry emergence. However, counter to what many scientists and engineers will tell you, emerging industries are not only driven by technology.

Chapter 4 presents how investment plays a critical role in the emergence of new industries because it facilitates the launching of firms, advancement of technology, refinement of production capabilities and supply networks, and development of markets. Investment is probably the most talked about element of emerging industries, but while it is important, the other elements in this book are also important because, for example, failing technology or market gaps, incompetent firm strategy, or misdirected government policy cannot be corrected solely with more investment.

Chapter 5 is about supply networks, which we describe as groups of individuals, firms, and institutions providing inputs for the development of a product or service, forming and growing as an industry emerges. The strongest supply networks encompass a wide variety of support industries, which aids in the development of alliances and benefits emerging industries, facilitating innovation and commercialization of technology.

Chapter 6 presents production, which plays an essential role for industry emergence, because technology remains a curiosity if we lack the ability to manufacture it into a product. We define production as involving the translation of ideas into reality, and production often facilitates the progression from invention to a commercialized product, leading to the emergence of an industry.

Chapter 7 describes how visionaries, early adopters, and eventually followers build markets for new industries. The rate of adoption of a technology depends on features of both the technology and the potential market.

Chapter 8 shows how government plays a special role in influencing all the other elements in the book. It is this omnipresent influence on all the other elements that makes government so special, and is its unique characteristic.

Chapter 9 focuses on the interaction of the elements influencing industry emergence described in the preceding chapters and elaborates on the concept of synchronization and its importance for the emergence of new industries. Element interaction and synchronization are related concepts because the interaction of the elements can result in co-development and coordination leading to synchronization. This chapter also elaborates on our three states of industry emergence – Concept, Validation, and Diffusion.

Chapter 10 presents how this book can provide inventors, firms, investors, scholars, and policymakers with understanding about how industries emerge and enable them to be more successful at influencing the birth and growth of new industries. We envision this book helping multiple parties as they play their roles in the emergence of an industry, but we also seek to continue the conversation about how to better understand and encourage the emergence of new industries.

Acknowledgments

This book began as a program on Emerging Industries funded by the UK Engineering and Physical Sciences Research Council (EPSRC) and the Gatsby Foundation. The program was led by Sir Michael Gregory, the Head of the Institute for Manufacturing (IfM) in the Department of Engineering at the University of Cambridge. I thank Professor Gregory for the opportunity he gave me to work on this research project and learn about this fascinating topic. Paul Heffernan was an early collaborator and leader, and he participated in many engaging conversations about the ideas in this book, and it would not have developed the way it has without his contribution. Many researchers (David Probert, Rob Phaal, Eoin O'Sullivan, Michelle Routley, Simon Ford, Tim Minshall, Nicky Dee, Finbarr Livesey, Laure Dodin, James Moultrie, Alex Driver, Ken Platts, Sirirat Lim, Jag Srai, David Kirkwood, Carol Walton, and Daniela Manca) were part of the IfM team participating in stimulating conversations and contributing significant insights that helped shape this book. My editor at Routledge Press, Sharon Golan, has been extremely supportive throughout the process of writing this book as she showed great confidence and belief in me and the importance of writing this book.

I have taught the material in this book to over 1,000 students, and their questions, research, and case studies have helped me improve the focus and explanation of the book's concepts and the relevance of the case study industries. Jordan Theyel provided valuable editing of multiple drafts, up-to-date, first-hand insight on many of the case studies, and useful ideas for improving the accessibility of the concepts. Marshall Theyel helped me with data analysis and mapping, particularly for the biotechnology and regenerative medicine case studies. Elizabeth Gamsey offered valuable insight and encouragement throughout the process suggesting literature and conceptualization of systems, evolutionary economics, and firm growth. Kay Hofmann read the entire book and offered valuable insight throughout. Allison Lau helped research

and write the wearable healthcare devices case study. Amanda Gresham helped research and write the electric vehicle and social networking case studies. Adam Zwicker offered a valuable student's perspective on how the ideas throughout the book could be communicated more clearly and effectively. Finally, I acknowledge my wife, Nelli Theyel, who made writing this book much easier with her clear and helpful insight throughout the entire process, and who makes my life much happier and fulfilling.

Contents

<i>List of Figures</i>	vi
<i>Preface</i>	vii
<i>Acknowledgments</i>	x
1 Understanding Industry Emergence	1
2 Firm Strategy	11
3 Technology	22
4 Investment	32
5 Supply Networks	43
6 Production	53
7 Markets	62
8 Government	74
9 Synchronization for Industry Emergence	84
10 Strategic Management for Industry Emergence	98
<i>Index</i>	103

1 Understanding Industry Emergence

Learning Objectives:

- Describe emerging industries
- Identify key elements affecting industry emergence
- Understand element synchronization
- Distinguish states of industry emergence

Key Concepts:

- Industry emergence
- Elements affecting industry emergence
- Synchronization
- States of industry emergence

1.1 Introduction

Emerging industries are groups of companies developing around a new, often disruptive idea, technology, product, or service. But why do industries emerge at such different rates? For example, why has the digital camera industry emerged since the mid-1990s to close to complete dominance today, while the solar photovoltaic industry is contributing only about 5 percent of electric power generated after more than 50 years of growth? The answer to this question is complex, just as is the process of industry emergence. This book explains how industries emerge when key elements such as firm strategy, technology, investment, supply networks, production, markets, and government interact and synchronize. **Synchronization**, or the coordination of multiple elements so that they reach a particular state simultaneously, is the key concept for industry emergence, because just as a conductor keeps an orchestra synchronized or as synchronized swimmers are coordinated in time, so too must important elements be synchronized in order for an industry to emerge.

2 *Understanding Industry Emergence*

The emergence of new industries is a complex and dynamic process, and it is vital because of the potential it offers for the advancement of technology, improvements in human health and the environment, growth of firms, creation of jobs, and economic development. Understanding how industries emerge is informative for inventors, firms, investors, and policymakers. Inventors and firms can benefit from a better understanding of the multiple elements influencing the progress of their technology. Investors can make better-informed decisions about their funding of companies, and policymakers can coordinate their efforts with technology, investment, markets, and firm strategy.

This book draws on multiple disciplines to illuminate industry emergence and present a framework of elements that influence how industries emerge. It shows the synchronization of the elements and the states of industry emergence and uses many case studies of emerging industries to support the usefulness of the framework. The unit of analysis for the book is the industry. This book is not specifically about emerging technologies, firms, markets, or countries. While all of these topics can be related to emerging industries, this book's contribution is a better understanding of how industries emerge. This chapter describes and explains emerging industries, presents a framework of elements for explaining industry emergence, and introduces the concepts of synchronization and states of industry emergence.

1.2 *Industries and Emerging Industries*

This chapter and book present industry emergence and its special nature and the interaction, co-evolution, and synchronization of important elements affecting new industries. But first, it is necessary to define industries and describe their growth in general.

1.2.1 *Industries and their Growth*

An **industry** is a group of firms aiming to meet the needs of a target group of customers with similar products and/or services. Within an industry, firms choose from multiple strategic positions. Firms can offer cost-leading products or services, or they can differentiate with luxury, or highly innovative products or services. Firms may have similar offerings or different offerings that provide similar utility, for example renewable energy firms may offer the same technology or a different technology that still generates electricity. Firms may choose to focus on different types of value chain activities. For example, some firms develop and produce products, while others market and sell them. A firm is described

as vertically integrated if it is involved in all industry value chain activities. Unless a firm is vertically integrated, it relies on other companies for complementary resources to deliver a product or service. Firms' roles change depending on where they are in an industry value chain. Firms that develop and produce products have suppliers that provide raw materials. They are in turn considered suppliers to their customers who sell their products. These customers sell their products to end users, who are their customers. Thus, an industry is a complex system of firms, with each contributing to meeting the needs of a target group of customers.

Many authors have suggested patterns for the growth of industries.^{1,2} Common approaches suggest that there is an initial phase where technology develops and firms vie for leadership. New ideas are explored, developed, and experimented with in order to see the direction of the technology and market. Over time, a standard is approached and there is what is referred to as a 'shakeout' of the firms that do not win the technology/product/business model standards battle and go out of business or are acquired. The winners with their standard setting technology, product, and/or business model lead an industry takeoff, or high growth period. With fewer competing firms and a growing market, sales usually increase, as do investment and profits. This is when production turns its focus to scaling for greater efficiency, supply chains develop, and the industry moves toward maturity. Decline and potentially rebirth follow industry maturity. This briefly describes the lifecycle for industries in general. The next section shifts our focus to industry emergence, where it will remain for the rest of the book.

1.2.2 - Emerging Industries

Emerging industries are groups of companies developing around a new, often disruptive idea, technology, product, or service. They are new industries offering utility through new technology, products, or services to a group of customers. They often have new value chains and supply networks and are driven by a "disruptive idea (or convergence of ideas)"³ that turns into a new product or service and a new industry. New industries emerge when entrepreneurs succeed in mobilizing resources in response to perceived opportunities.⁴ These perceived opportunities motivate individuals and firms to focus their limited resources in a particular direction. These risk-takers hope that their hunch about an opportunity and the quality of their resources will be the right match for success.

The emergence of a new industry can be seen as a process that is based on a technological innovation meeting a new or existing customer need.⁵

4 *Understanding Industry Emergence*

A technological breakthrough is often responsible for a new industry. However, this breakthrough needs to meet the new or existing customers' needs better than alternatives, usually both on utility for customers and on price.

Emerging industries are said to be characterized by "novel and coherent structures, patterns and properties driving the process of self-organization in complex systems,"⁶ and are described as "newly formed industries that have been created by technological innovations, shifts in relative cost relationships, emergence of new customer needs, or other economic and sociological changes that elevate a new product or service to the level of a potentially viable business opportunity."⁷

Common elements in the descriptions of industry emergence include technological innovation, market needs and opportunities, entrepreneurs, and complex systems. These descriptions imply interaction, co-development, and synchronization of the elements. Emerging industries are complex, and understanding them calls for an organized and systemic approach. Therefore, we integrate the descriptions above and present industry emergence as **the birth and early growth of new industries shaped by the interaction and synchronization of the strategic behavior of firms, technological innovation, investment, supply networks, production, markets, and the influence of government and other institutions**. We use this description to guide our development of a framework and our understanding of the elements that drive the growth of new industries. In the next section we present our framework, examining the interactions and synchronization of critical elements for industry emergence, with the help of example emerging industries.

1.3 Framework for Understanding Industry Emergence

The seven elements—firm strategy, technology, investment, supply networks, production, markets, and government—that we represent as horizontal 'process bands' in Figure 1.1 show the changes that generally occur as an industry emerges. The order of the elements is not meant to imply an order of importance. Instead, different elements are more or less important depending on the characteristics of specific emerging industries. This is made clear through the many emerging industry case studies presented throughout this book.

Vertically, we show three states of emergence: Concept, Validation, and Diffusion. The elements must be synchronized in order for an industry to grow from one state of emergence to the next. The seven elements and three states of emergence are based on the contributions of many

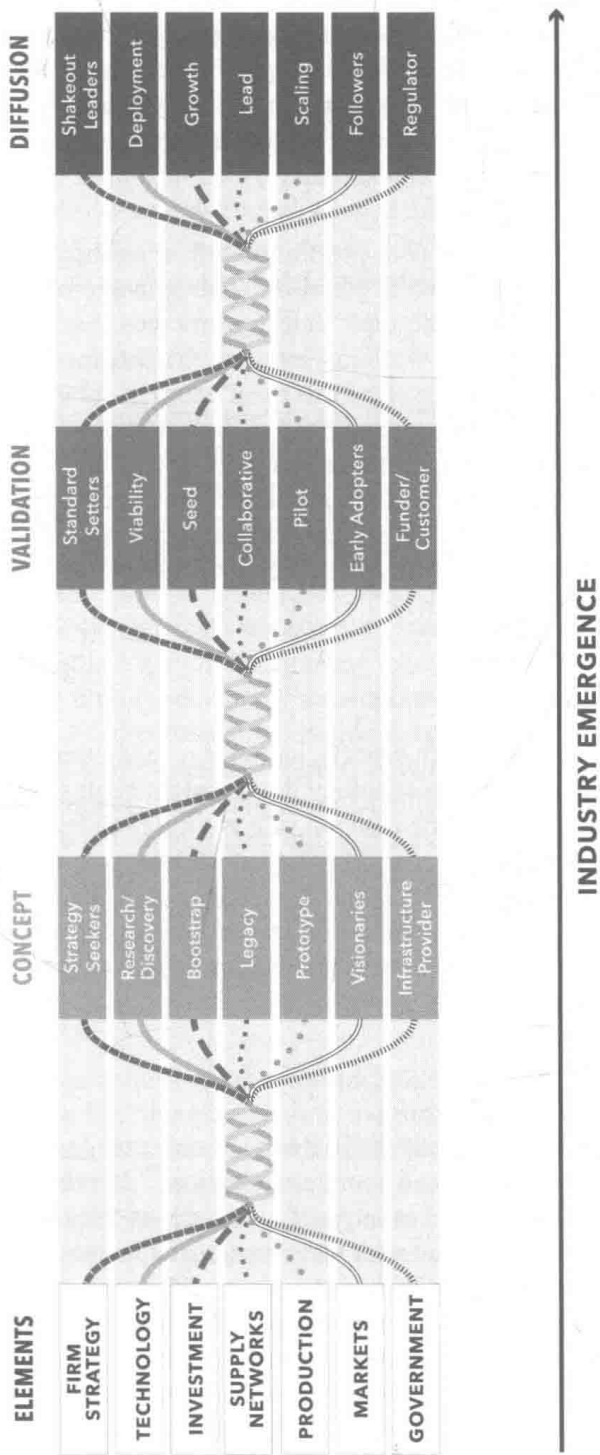


Figure 1.1 Framework for Understanding Industry Emergence.

authors. In the following section, we summarize an array of insights from numerous disciplines, including engineering, management, economics, and political science, in order to assemble our interdisciplinary framework for understanding industry emergence.

1.3.1 Firm Strategy

Firm strategy is how a firm positions itself in an industry and how it uses resources to support its position.⁸ The strategic options, or positions, for firms change as their industry emerges. Early entrant firms search for opportunities while an industry first begins to emerge, followed by firms that set the standards in an industry, for example, Intel in the microprocessor industry and Ford in the automobile industry. Firms begin to compete for market share as an industry emerges and grows. As industry emergence continues, shakeout occurs as new industry entrants join in and others exit or are acquired, as the focus shifts from product to process innovation, and firms that excel at operational effectiveness lead the industry (see Figure 1.1).⁹

1.3.2 Technology

Technology entails design aspects, knowledge, and often physical components. The process of technology development begins with a research discovery, followed by the creation of a working model of the technology, that is, proof of the viability of the technology, and then advancement to deployment, which is the functional use of the technology (see Figure 1.1). Gaps in this progression may slow or even prevent the emergence of an industry, as some technologies do not advance to viability and deployment.

1.3.3 Investment

Investment often represents the lifeblood of research, innovation, development of value chains, and commercialization.¹⁰ **Investment**, or financial resources committed to support a venture, is usually essential for an industry to emerge, and with this emergence the nature and extent of investment opportunities change. As illustrated in Figure 1.1, the availability and sources of investment are likely to vary over time as the other elements that affect emerging industries change.

Entrepreneurs often provide their own early financial resources, in what is called “bootstrapping.” As an industry continues to emerge,