

Technological Progress and Industrial Leadership

**The Growth of the U.S. Steel Industry,
1900–1970**

Bela Gold

Claremont Graduate School

William S. Peirce

Case Western Reserve University

Gerhard Rosegger

Case Western Reserve University

Mark Perlman

University of Pittsburgh

LexingtonBooks

D.C. Heath and Company

Lexington, Massachusetts

Toronto

Contents

	Figures	xiii
	Tables	xix
	Preface <i>Bela Gold</i>	xxv
<i>Part I</i>	<i>Analyzing Technological Progress: Concepts, Measures, and Results</i> <i>Bela Gold</i>	1
Chapter 1	Mythology, Needs, and Objectives	3
	Some Elements of the Prevailing Mythology	4
	Common Obstacles to Analysis	6
	Objectives and Plan of Study	8
Chapter 2	Technological Change: Concepts and Models	15
	Nature and Types of Technological Change	15
	Sources of Technological Advances	19
	Objectives of Technological Improvement Efforts	24
	Effectiveness of Technological Improvement Efforts	28
	Technological Progress: Nature and Levels	31
Chapter 3	Harnessing Technological Innovations	43
	Appraising Diffusion Patterns	43
	Foundations of Technology Decision Models	48
	Stages of Decision Making	55
	Components of the Decision Model	57
	Making the Decision	60
	Factors Affecting Decisions by Later Adopters	63
Chapter 4	Evaluating the Effects of Technological Innovations: Prevailing Approaches	77
	Differing Study Objectives	77
	Alternative Analytical Focuses	82
	Relevance of Concepts and Measures Used	85

	Vulnerability of Interpretations of Past Findings	90
	Conclusions and Implications	94
Chapter 5	Evaluating Innovational Effects: Managerial Criteria	103
	Management's Requirements for Evaluating Prospective Innovations	103
	Basic Structure of Productivity-Cost-Profitability Analysis System	106
	Effects of Changes in Technology and Productivity Relationships	115
	Hypotheses Concerning Innovational Effects	119
Chapter 6	Evaluating Broader Innovational Effects	125
	Repercussions in Adjacent Industrial Sectors	125
	Evaluative Criteria in Larger Sectors of Industry	128
	Additional Governmental and Social Criteria	138
Chapter 7	Measurement Problems and Expedients	143
	General Difficulties	143
	Output Levels	144
	Input Levels	146
	Product and Factor Prices	148
	Unit Costs and Real Costs	150
	Productive Capacity and Utilization	151
	Some Additional Measurement Requirements	156
	Some Broader Methodological Issues	157
<i>Part II</i>	<i>Technological Progress and Economic Effects in Coal and Iron Mining William S. Peirce</i>	161
Chapter 8	Technological Changes in Bituminous Coal Mining	163
	Breaking Coal from the Face	163
	From Coal Face to Mine Mouth	166
	Other Aspects of Underground Mining	177
	Surface Mining	178
	Preparing Coal for Coking	185

	Some Basic Patterns	186
Chapter 9	Physical Performance in Coal Mining	193
	Total Output	193
	Output per Man	196
	Consumption Patterns	199
	Capacity and Utilization of Mines	204
	Number of Mines	208
	Size of Mines	211
	Technological Change and Reserves	213
	Technological Change and the Environment	221
	Captive Mines	224
	Conclusions	229
Chapter 10	Economic Performance in Bituminous Coal Mining	237
	Total and Unit Costs and Value	237
	Factor Prices and Unit Input Requirements	248
	Unit Costs and Output	264
	Costs as a Proportion of Sales and Value Added	265
	Profits and Rents	268
	Conclusions	282
Chapter 11	Technological Change in Iron Ore Mining	291
	Technological Change in Underground Mining	291
	Technological Change in Open Pit Mining	298
	Beneficiation	304
	Conclusions	311
Chapter 12	Physical Performance in Iron Ore Mining	321
	Physical Output	322
	Fluctuations in Output	324
	Imports and Exports	327
	Geographic Shifts	330
	Quality of Ore	334
	Output per Man-Day	339
	Number and Size of Mines	341
	Production and the Change in Reserves	344

	Conclusions	347
	Appendix 12A: The Price of Iron Ore	351
Chapter 13	Economic Performance in Iron Ore Mining	357
	The Economic Setting	357
	Total and Unit Costs and Value	362
	Factor Prices and Unit Input Requirements	373
	Total Unit Value and Output	386
	Costs as a Proportion of Sales and Value Added	387
	Profitability	393
	Conclusions	395
	Appendix 13A: Rent, Royalties, Taxes, and Technology	401
Chapter 14	Transportation of Iron Ore	415
	Technological Changes on the Great Lakes	415
	Economic Outcome	429
	Competitive Modes and Routes	433
	Conclusions	441
<i>Part III</i>	<i>Technological Progress and Economic Effects in Iron and Steel Production Gerhard Rosegger</i>	447
Chapter 15	Technological Change in the Coking Industry	449
	Technological Change	450
	Performance of the Coke Oven Segment	453
	Relationship of the Coke Industry to the Blast Furnace Segment	465
Chapter 16	Technological Change in the Blast Furnace Segment	469
	Patterns of Technological Change	471
	Summary and Conclusions	484
Chapter 17	The Blast Furnace Segment: Physical Performance	489

	Development of Capacity and Scale of Operations	489
	Production and Capacity Utilization	492
	Labor Inputs Relative to Output	496
	Productivity of Raw Materials	502
	Summary and Conclusions	507
Chapter 18	The Blast Furnace Segment: Economic Performance	511
	Changes in Output Value and Average Price or Output	512
	Changes in Unit Material Costs	515
	Changes in Unit Employment Costs	518
	Changes in Overhead Costs and Profits	520
	Changes in Cost Proportions	525
Chapter 19	Technological Change in Primary Steel Making	529
	Technological Change, 1899–1930	530
	Technological Change, 1931–1970	543
	Summary and Conclusions	552
Chapter 20	Technological Change in the Mechanical Treatment of Steel	559
	Background	561
	Development of Power Sources	563
	Technological Change in Steel Rolling	565
	Technological Change as Reflected in Output Mix	571
	Summary and Conclusions	573
Chapter 21	Primary Steel Making: Physical Performance	579
	Development of Total Output and Capacity Utilization	579
	Development of Plant Size and Scale of Equipment	583
	Changing Shares of Steel-Making Processes in Total Output	586
	Ferrous Materials Inputs	593
	Consumption of Oxygen and Fuels	601

x	Technological Progress and Industrial Leadership	
<i>Part IV</i>	<i>The Larger Setting</i>	607
Chapter 22	Governmental Intervention and the Socioeconomic Background <i>Mark Perlman</i>	609
	Major Developments by Periods	609
	Analyzing the Lessons	624
	Assessments	627
Chapter 23	International Steel Production and Trade <i>Gerhard Rosegger</i>	633
	U.S. and World Steel Production	635
	Developments in Raw Materials Trade	640
	Development of Exports and Imports	642
	Product Composition of Exports and Imports	646
	Changes in Trading Partners	650
	Summary and Conclusions	653
<i>Part V</i>	<i>Conclusions and Implications</i> <i>Bela Gold</i>	659
Chapter 24	Economic Performance of the Iron and Steel Industry	661
	Needed Revisions of Our Research	
	Objectives	661
	Summary of Key Innovations and Expected Effects	663
	Diffusion Patterns Compared with Expectations	665
	Actual Growth and Cost Patterns Compared with Expectations	667
	Cost Determinants: Adjustments in Productivity and Factor Prices	670
	Resulting Changes in Industry Costs and Profitability	679
	Appendix 24A	685
Chapter 25	Changing Perspectives on the Economic Effects of Technological Advances: Some Implications of the Empirical Findings	693
	Some Empirically Rooted Revisions of Prevailing Expectations	693

	Managerial Approaches to Improving Technological Capabilities	708
	Approaches to Evaluating Prospective Technological Innovations	709
	Generating Proposals for Technological Innovations	714
	Evaluating the Results of Installed Technological Innovations	717
	Concluding Observations	721
Chapter 26	Some Strategic Perspectives	727
	Pressures toward Restructuring the World Steel Industry	727
	Prospective Adjustments in Response to Pressures	742
	Resulting Challenges to Management and Governmental Policies	755
	Concluding Observations	767
	Index	777
	About the Authors	797