Index

Abernathy, William J., 124 early Detroit leaders and, 95-96, 98, 100, 102 spin-offs and, 105, 110, 115-116 Absorptive capacity, 384 Acceptable use policy (AUP), 308 Acetylene gas, 52 Ackerman, Robert C., 118 Adams, Stephen B., 46 Adams-Bagnall Electric Company, 54 Aghion, P., 414, 436 Aircraft industry, 98, 129, 297 Air Mail Act and, 185, 192 civil aircraft and, 191 computers and, 327 information technology (IT) and, 283 Kelly Bill and, 185–186 Lindbergh and, 186–187 McNary Watres Act and, 191–193 passenger revenues and, 191 production collapse of, 190-191 U.S. military and, 185, 191 U.S. Post Office and, 185, 188, 191-193 U.S. Stock Market and, 182–193, 197, 199 World War I and, 183 Wright brothers and, 182 Air Mail Act, 185, 192 Akerlof, George A., 409 ALCOA, 52 Allied Chemicals, 228

A. L. Moore Company, 59 American Bicycle Company, 56, 59 American Bosch Magneto Corporation, 227-228 American Exchange National Bank, 58 American Marconi, 194 American Multigraph, 45 American Optical, 261 American Telephone and Telegraph (AT&T), 20, 249–250 1956 consent decree and, 293 computers and, 290, 297, 318 fiber-optic technology and, 262–263, 265 lasers and, 260 Lucent Technologies and, 273 MCI and, 254, 268, 272 monopoly of, 252–253, 264–265, 272, 278n12, 312n3 patents of, 261 semiconductors and, 288-290 U.S. Stock Market and, 194, 228, 230, 232 Western Electric and, 263 Anand, B. N., 367–368, 387 Andreesen, Marc, 308 Annual Reports of the Commissioner of Patents, 61, 66 Antitrust policies, 20, 312n3 IBM and, 330, 347-348 telecommunications and, 251, 264 Apollo program, 301

Arc-lighting system, 47, 55. See also Brush Electric Company Arc-welding, 54 Argentina, 144 Ark club, 47 Armistead, Bill, 259, 261, 269-270, 275 Armstrong, Jeff, 436, 438, 441, 445 Arnold, Thurman, 251 Arora, Ashish, 1, 25, 365–403 ARPANET, 306-308 Arrow, Kenneth J., 21, 285, 309, 365, 368 Asian Venture Capital Journal, 425 Athreye, S., 367 Atje, Raymond, 170 Atomic Energy Commission, 98, 297 Australia, 143 Automobile industry. See also Specific company aircraft and, 182-183 carriage companies, 100-101, 115–116, 118, 180 Corning Glass Works and, 256, 270n14, 279n14 de novo entrants and, 91 early Detroit-area leaders of, 94-104 entrant origins, 91-94 experienced firms and, 91 foreign competition and, 85 growth of, 87-90 heyday of, 85 historical perspective of, 87-90 inexperienced firms and, 91 moving assembly line and, 96 NYSE and, 179–180 parts contracts and, 108-109 production methods and, 88, 95–96, 99 - 100recession of 1920 and, 112-113 spin-offs and, 86, 91–92, 104–126 subcontracting and, 96–97, 103–104, 123 survival curves and, 92-94 U.S. Stock Market and, 164, 175 - 182

Automobile Quarterly, 89 Automobiles, 13–14, 17, 54, 60, 77n16, 130 Britain and, 152–153 Cleveland, Ohio and, 42 electric, 56, 88 financial experiments of 1890s and, 134 gasoline, 60, 88, 94-95 steam, 81n43, 88, 94 tiller steering and, 88 Aviation Corporation (AVCO), 190 - 192Aviation industry, 17–18 auto industry and, 182-183 growth in, 185–193 U.S. Stock Market and, 164–165 AVIDAC, 295 Bachie, Andrew, 119 Bailey, L. Scott, 89, 94–95, 98, 100 Baker, George W., 59–60 Baker, Walter C., 55, 59–60 Baker Motor Vehicle Company, 55 Bancamerica-Blair Corporation, 189 Banerjee, Abhijit V., 436 Banks Cleveland, Ohio and, 40–45, 58 deflation effects and, 137–158 entrepreneurs and, 411 Federal Reserve System and, 131 General Motors and, 102, 177-178 German Reich and, 153 information technology (IT) and, 283 joint stock, 130 Liberty loans and, 199 patents and, 6 Second Industrial Revolution and, 131 Victory loans and, 199 Baran, Paul, 305 Barbour, William T., 105 Barro, Robert, 234 Barron's, 195–196 Barsky, Robert B., 218 Bascavusoglu, E., 369

Baskin, Jonathan, 168 Batteries, 49 Bayh-Dole Act, 311, 472 Bell Laboratories, 339, 471 semiconductors and, 288-289 telecommunications and, 249-250, 254, 262–264 Belmont, August, 55 Belmont, Perry, 55 Bendix Aviation, 297 Bentley, Edward M., 51, 57, 78n20 Bentley-Knight Electric Railway Company, 51, 57 Berners-Lee, Tim, 308 Bethlehem Steel, 238–239 Bezner, Frederick, 108, 110 Bicycles, 56, 59, 97–98, 120 Big Board, 18 Bikhchandani, Sushil, 436 Bioscan, 440, 442 Biotechnology, 434, 438 firm governance and, 417-425 knowledge capital and, 441–442 rDNA, 441-442, 446-447, 450-451 Bishop-Babcock-Becker Company, 45 Black-McKellar Bill, 185, 192 Blair & Company, 189 Blanchard, Oliver, 234 Boeing, William, 183 Boeing Airplane Company, 183–184, 187, 189-190, 192 Bolt, Beranek and Newman, 305–306 Bond, Stephen R., 222 Bonds, 44-45. See also U.S. Stock Market clearing mechanisms and, 140 deflation effects and, 137-158 Second Industrial Revolution and, 133 - 158Borden, Gail, 12 Boston Consulting Group, 269 Boulton Carbon Company, 49, 79n29 Bradey, Anthony N., 55 Brady, 108–109 Branstetter, L. G., 369 Braudel, Fernand, ix-x

Brazil, 473 Bresnahan, T., 221, 372 Bridgman, Percy, 240 Briscoe, Benjamin, 97, 100, 103, 106, 112, 122-123, 178 Briscoe, Frank, 97, 100, 103, 106, 112, 122-123 British Post Office (BPO), 253, 260 - 261British Telecom, 253 Broadway Savings and Trust, 44 Brown, Alexander E., 75n1 Brown, Fayette, 44 Brown, Harvey H., 44–45, 75n1 Brown, Walter Folger, 191 Brown Hoisting Machine Company, 44 - 45Bruchey, Stuart, 201 Brush, Alanson, 96, 111–112, 117, 122 Brush, Charles F., 12, 47-48, 50, 123 Brush Electric Company, 15, 41, 62, 74-75, 103-104 arc-lighting systems and, 47-48 demonstration effect and, 47–50 ease of capital for, 49-50 employee ideas and, 53-54 inventors and, 50-56 limited role of financial institutions and, 56-58 mergers and, 54–55 networking and, 50-56 Brush Runabout Company, 111–112, 121 - 123Brynjolfsson, Erik, 221–222, 234–235 Bubbles, 19, 131 Budd, Edward, 115 Buderi, Robert, 252, 266 Buick, David, 101–103 Buick Motor Company, 124–125, 177Chevrolet and, 117–118 early years of, 94, 100-104 Maxwell and, 106 Model 10 and, 117

Building-and-loan associations, 44 Burdett, Henry, 149 Burgess Aeroplane Company, 183 Butler, Orville R., 46 Bygrave, W., 207 Caballero, Ricardo, 224 Cable, 269–270 Cadillac Motor Car Company, 123-125, 177 Brush Runabout Company and, 111 - 112Lincoln Motor Company and, 112 - 113Oakland Motor Car Company and, 112 organization of, 94, 97-105 spin-offs from, 111-113 Cailliau, Robert, 308 Calcium carbide, 52 Calhoun, Craig, xi Cameras, 220 Campbell, Van, 259 Campbell-Kelly, M., 300-301 Canada Cable and Wire, 268 Cantwell, J., 367 "Capital Market Myopia" (Sahlman and Stevenson), 206-207 Carlson, W. Bernard, 14 Carnegie Mellon Survey, 25, 376-377, 380, 383-384 Carosso, Vincent P., 200 Carothers, Wallace, 220 Carriage companies, 100–101, 115-116, 118, 180Carter, Richard, 446 Case School of Applied Science, 47, 60 Cassiman, B., 369 Ceccagnoli, Marco, 25, 365-403 Celcor, 273 Central Trust Company of New York, 178Cerf, Vinton, 306 CERN, 305, 308 Cetus Corp., 440

Chalmers, Hugh, 109–111, 115, 120-124, 180 Chalmers-Detroit, 30, 109–110 Chalmers Motor Co., 111 Chance Vought Corporation, 189, 192 Chandler, Alfred, x, 221–222 Chandler, Frederick, 120, 180 Chandler-Cleveland, 181 Chandler Motor Company, 120 Chapin, Roy D., 107–110, 121–123 Chatham and Phoenix National Bank of New York, 178 Chemicals, 13–14, 220, 228, 385 Cleveland, Ohio and, 42, 44 Corning Glass Works and, 260 financial experiments of 1890s and, 132 Chevrolet, Louis, 117–118 Chevrolet Motor Car Company, 117–118, 121, 124, 180–181 Chia, Robert Kay Guan, 425 Chicago, 18, 140, 142–143, 202 Chicago Research Center in Securities Prices, 222 China, 426, 473 Christie, Milton, 209 Chrysler, Walter, 104, 121, 124 Chrysler Corporation, 85, 87–88, 120 - 121Civilization and Capitalism (Braudel), ix Clark, Kim B., 124 early Detroit leaders and, 95–96, 98, 100, 102 spin-offs and, 105, 110, 115-116 Clement, J. R. B., 299 Cletrac, 60 Cleveland, Ohio, 14–18, 39 automobiles and, 42 banks and, 40–45, 58 Brush Electric Company and, 46–58, 74 - 75chemicals and, 42, 44 financial information sources and, 46 - 61

financial sector of, 41-46 historical perspective of, 41-42 iron ore and, 42 location of, 41–42 machine tool industry and, 42 manufacturing sector of, 41-46 Monumental Park and, 48 patents and, 42 post-Civil War growth in, 42 quantitative patterns in, 61-73 stock market and, 142-143 Telegraph Supply Company of Cleveland and, 47-48, 56 trust companies in, 42, 44 White Sewing Machine Company and, 45, 55-61 Cleveland Machine Screw Company, 56, 59-60 Cleveland Malleable Iron Company, 44 Cleveland Motor Plow Company, 60 Cleveland Plain Dealer, 45 Cleveland Stock Exchange, 40, 44–45, 57,60 Cleveland Trust Company, 40, 44, 77n10 Cleveland Twist Drill Company, 44, 48 Coal, 130 COBOL, 301-302, 304 Coca Cola, 227 Coffin, Howard, 95, 107–110, 121 - 125Coggeshall, Porter E., 442 Cohen, Jon S., 155 Cohen, Wesley M., 25, 228, 365-403 Comer, G. P., 228 Commercial and Financial Chronicle, 61, 172, 217-242 Commercial Bank of Lake Erie, 44 Commercial National Bank, 44 COMPUSTAT database, 444 Computer Control Corporation, 297 Computers, 22, 234–235, 240–241, 273 advanced processing and, 318

card-programmed calculator and, 326-330 federal R&D and, 283-284, 294-305, 317-319 IBM and, 326-328 (see also International Business Machines (IBM)increased capability of, 318 information and, 294-300 Internet and, 305–309 massive public investment in, 317 punched cards and, 322-330 software industry and, 300–305 solid state, 338-343 Computer Sciences Corporation, 300 Computer Usage Company, 300 Con artists, 49 Consolidated Aircraft Corporation, 184, 190 Consolidated Exchange, 140–141 Consumer Price Index, 443–445 Control Data Corporation (CDC), 347 Coombs, Joseph E., 436–437 Cornell University, 51, 59 Corning Glass Works, 19-20 antitrust policies and, 251, 264 "associations" of, 250-251, 265 - 266British Post Office and, 253, 260 - 261business plan of, 255-256, 272-277 cable technology and, 269-270 capacity building and, 270-272 corporate structure of, 258-259 creative response and, 247, 276-277 diversity of, 273-274 electrical components and, 255 family-owned stock of, 251 fiber-optic technology and, 259-277 financial risks of, 248 "The Guns of August" and, 271 Houghton and, 259, 267, 269-270, 274-275 intellectual property issues and, 266-269

Corning Glass Works (cont.) joint ventures and, 250-251, 265 - 266, 269lawsuits by, 267-269 licensing issues and, 262-264 long-term funding and, 265-266 Lucy and, 261–262, 265 marketing strategies of, 270-272 Maurer and, 249, 261-262, 266 - 267MCI and, 268, 272, 275 post-World War II era and, 255-256 productivity vs. creativity and, 248 - 249project documentation and, 266-267 proprietary knowledge and, 251–252 Pyrex and, 254 research and development (R&D) and, 248-249, 255-259 resource allocation and, 257 Sullivan Park and, 249 technology strategy of, 259-260 telecommunications industry and, 254-256 television picture tubes and, 255 uncluttered path approach and, 250 - 251Western Electric and, 263 windshields and, 256, 270n14 Corning Ware, 254 Covington, Edward J., 54 Cowles, Alfred H., 51, 56-57 Cowles, Eugene, 51, 56-57 Cowles Electric Smelting and Aluminum Company, 51–52, 57 Cox, Jacob D., 44, 48 Crawford family, 54 Creative destruction, 247 Creative response, 247, 276–277 Cross-licensing, 262–264 Crystal Palace exhibition, 3, 471 Cull, Robert J., 45 Cummins, Jason G., 222 Curtiss, Glenn, 182-183 Curtiss Aeroplane and Motor Corporation, 183-189

Curtiss-Robertson Airplane Manufacturing Company, 187 Curtiss-Wright Corporation, 190 Curved-Dash Runabout automobile industry organization and, 95-102, 105-108, 113, 125 Brush Runabout Company and, 111 - 112Dalzell, Fred, 252 Darby, Michael R., 26-27, 433-467 Dark, Frederick, 446 David, Paul, 221, 240–241 Davis, Lance E., xi, 16–17, 45, 74, 115, 129-161 Dawson, Al, 270 Dayton-Wright Company, 183–184 Debugging, 284 Decarolis, Dona, 436–437 DECNET, 306 Deeds, David L., 436–437 Deeds, Edward A., 183 Deere, 142 Defense Calculator, 320 Deflation financial experiments of 1890s and, 133 - 137Germany and, 153–155 Great Britain and, 143–153 United States and, 137–143 World War I and, 149 World War II and, 151 De Forest, Lee, 193 De Forest Radio, 194–195 DeLong, J. Bradford, 217–218 Demonstration effect, 97 fiber-optics and, 262 Lindbergh and, 186–187 Second Industrial Revolution and, 47 - 50, 53Denby, Edwin, 115 Detroit, Michigan, 15–17 Buick Motor Co. and, 94, 100-104 Cadillac Motor Car Co. and, 94, 97-98 de novo entrants and, 91

early leaders in, 94–104 experienced firms and, 91-92 firm concentration in, 88–89 Ford and, 94, 97–100 historical perspective of, 87–90 inexperienced firms and, 91 Olds Motor Works and, 88-89, 94-97, 103-104 spin-offs and, 86, 91-92, 104-126 Detroit Aircraft Corporation, 190, 192 Detroit Automobile Company, 97 Detroit Edison Illuminating Company, 97, 99, 140 Detroit Stove Works, 105 Detroit Street Savings and Loan, 44 Devenow, Andrea, 417 Devine, Warren, 240 Dictionary of American Biography, 53 Digital Equipment Corporation, 306, 348 Directory of American Research and Technology, 376 Discounted cash flow (DCF), 257 DNA technology, 27 Dodd, Paul A., 183–186, 188, 190 Dodge, Horace E., 96–97, 116–117, 176 Dodge, John F., 96–97, 116–117, 176 Dodge Brothers, Inc., 77 Chrysler and, 121 Organization of, 99, 102–103, 116-117, 122-123 stock flotation by, 181-182 Doolittle, James, R., 123 Dort, Dallas, 101–102 Douglas Aircraft, 190 Dow Corning, 142, 251 Doyle, William M., 174 Drake, J. Walter, 114–115 Duke, Dave, 271 Dunham, Terry B., 117 Duplex Condenser and Radio, 194 - 195du Pont, Pierre, 178 Durant, William Crapo

automobile industry and, 98, 101–103, 112, 121–124, 177, 181 spin-offs founded by, 117-119 World War I and, 98 Durant-Dort Carriage Company, 101, 118, 123-124 Durant Motor Company, 118–119 Dyer, Davis, 251–252, 256, 258, 266, 270Dynamos, 47-48, 52-53, 55 Eads, G. C., 311 Earl Radio Corp., 196 East Cleveland Railway Company, 51 Eastman Kodak, 220, 222, 230, 232, 324 Eckert, J. Prespert, 295, 330, 328-329 Economic issues business cycles and, 130–131 creative response, 247, 276-277 deflation effects and, 137-158 ERISA and, 470 globalization and, 130, 469–470, 473 gold standard and, 130, 133-137 Great Crash and, 217–218, 241 Great Depression and, 166–167 intangible capital and, 217–242 New Deal and, 251, 264 NYSE and, 16–18 patents and, 3-12 (see also Patents) recession of 1920 and, 112–113 royalties and, 48 Second Industrial Revolution and, 13-15, 28, 39-75, 129-130 survival curves and, 92-94 U.S. Stock Market and, 163-211 (see also U.S. Stock Market) World War I and, 149, 155–157 World War II and, 151, 207 Economic Report of the President, 443 Eddy, George, 197, 204 Edgar, D., 299 Edison, Thomas, 12, 14, 46, 129, 227 Edson, E. R., 44

EDVAC, 295 E. I. du Pont de Nemours, 19, 178, 201computers and, 324 intangible capital and, 220, 222, 228, 230, 232 Eisenman, Harry J., 47, 58 Electric brakes, 53 Electricity, 13–14, 16, 150 Britain and, 152–153 Brush Electric Company and, 15, 41, 47 - 75dynamos and, 47–48, 52–53, 55 falling prices and, 221 financial experiments of 1890s and, 134 hydroelectricity and, 52 intangible capital and, 220-221 Lincoln Electric Company, 53–54 research and development (R&D) and, 372 Second Industrial Revolution and, 130 smelting and, 51–52 Thomson Houston Electric Company, 48, 51, 55 Electric machinery industry, 42 Electric motors, 54 Electro Gas Company, 52 Elliott, Emmett, 54 Elliott, Samuel K., 54 Elliott, W. H., 54 Elliott-Lincoln Electric Company, 54 Employee Retirement Income Security Act (ERISA), 470 Engineering Research Associates, 328 ENIAC, 295, 329 Entrepreneurs, 429, 471–472 agency problems and, 408–417 Asian contracts and, 425–428 asymmetric information and, 407, 409-410 banks and, 411 behaviorial explanations and, 415 - 417biotechnology and, 417-425

challenges of, 406-409 commercializing firms and, 12-21 contracting difficulties and, 413–415 employee ideas and, 53-54 functional approach and, 405 inexperienced parties and, 413 intermediaries and, 409-412 market conditions and, 408 nature of assets and, 407-408 patents and, 3-12 productivity vs. creativity and, 248 - 249research and development (R&D) and, 414, 417-425 shareholder value and, 408-409 suspicions of, 405 uncertainty and, 406-407 Equity markets, 45 E. R. Thomas-Detroit, 107–109, 121, 125 E. R. Thomas Motor Company, 108 Euclid Avenue National Bank, 58 European Patent Office (EPO), 224 European Union, 470 Everhart, Steve, 436–437 Everitt, Barney, 113–114, 121–122, 124 Everitt-Metzger-Flanders (E-M-F) Company, 113–114, 121–125, 178 - 179Ex ante technology contracting, 366, 377-378 Ex post technology contracting, 366, 368-370, 376, 378 Fabrizio, Kira R., 22, 283–316 Fairchild, 290, 318, 348 Fama, Eugene, 218 F. Eberstadt & Co., ix Ferleger, L., 191 Fessenden, Reginald, 193 Fiber-optic technology, 132 1960s development level of, 253 - 254AT&T and, 262–263

cable and, 269-270

capacity building and, 270-272 Corning Glass Works and, 259-277 creative responders and, 247 demonstration effect and, 262 intellectual property issues and, 266–269 knowledge base for, 248 lasers and, 260 licensing issues and, 262-264 long-term funding and, 265–266 marketing strategies for, 270–272 OV/IV processes and, 271–272 research and development (R&D) and, 248-249, 253-254 signal attenuation and, 249 Field, Alexander, 227, 241 Finance capitalism 1920s and, 197-203 creative responders and, 247 deflation effects and, 137-158 experiments of 1890s and, 133-137 government and, 131 historical perspective of, 130–133 London Stock Exchange and, 143 - 153New York Stock Exchange and, 137-143, 148-153 railroads and, 137-140 Schumpeter and, 130–131 stock issue effects and, 169-196 U.S. Stock Market and, 163-211 (see also U.S. Stock Market) Financial History of the American Automobile Industry, A (Seltzer), 175 - 176Financial World, 269 Fink, C., 369 Firestone Tire and Rubber, 231 Fish and Neave, 267 Fisher, Franklin M., 297–298 Fisher, Irving, 217, 220 Fisher Body, 180 Fisman, R., 369 Flamm, Kenneth, 295, 297, 302, 317 Flanders, Walter, 99–100, 106, 113-114, 120-124

Flint Wagon Works, 100, 118 Florida, Richard, 257 Flower, Roswell P., 55 Fogarty, Michael S., 42 Foley, C. F., 369 Ford, Harry, 110-111 Ford, Henry, 95–99, 102, 121, 123, 125, 176 Ford Motor Company, 85-89, 122, 124–125, 176 Dodge Brothers Motor Car Company and, 116–117 early years of, 94, 97–104 E-M-F Company and, 113–114 Hupp Motor Car Company and, 114 - 115interchangeable parts and, 100 Model N, 99-100 Model T, 88, 100, 116, 122 moving assembly line and, 96 NYSE and, 179–181 production methods and, 99-100 race cars and, 97 spin-offs from, 113–117 stock flotation and, 181 Forrester, Jay, 319 FORTRAN, 300 Fosfuri, A., 1, 367–369, 379, 385 France, 5, 265, 307 Franklin Institute, 48 Freed-Eiseman Radio Corp., 196 Freeman, Chris, x French, Kenneth, 218 Freudenthal, Elsbeth E., 183–190, 206 Functional approach, 405 Furman, 220 Galambos, Louis, 252, 258 Galbraith, J. K., 241 Gallaudet Aircraft Company, 184 Gallini, Nancy, 411 Gambardella, Alfonso, 1, 365–367, 374, 379, 385

Gans, J., 1, 368, 380, 383 Garfield Savings Bank, 58 Garofalo, Gasper S., 42 Garvey, Ed., 338, 341 Garvy, G., 201 Gasoline automobiles, 60, 88, 94–95 Gross Domestic Product (GDP) measurement, 17, 169-170, 219, 428 Geijsbeek, W. R., 257 GenBank, 441 General Electric, 14, 16, 19, 54, 56, 199 computers and, 297 IBM and, 340 intangible capital and, 220, 222, 228, 230, 232, 241 Langmuir and, 220 Radio Corporation of America and, 193-194 semiconductors and, 289 Generalized method of moments (GMM), 458 General Motors, 19, 85, 87-88, 124, 199, 201, 471 banks and, 177–178 Buick Motor Co. and, 94, 100–102 Chevrolet and, 117–118 Durant and, 98, 101–102, 112, 177-178, 181 financial troubles of, 102 founding of, 101–102 intangible capital and, 221-222, 231-232 Leland and, 98 Maxwell-Briscoe and, 106 Model T and, 117 NYSE and, 179–180 Oakland Motor Car Company and, 112 Olds Motor Works and, 97 spin-offs and, 104 World War I and, 98 Germanium, 341 Germany, 132, 156-158, 369 Corning Glass Works and, 265–266 deflation effects and, 153–155 entrepreneurs and, 411

financial experiments of 1890s in, 133 - 137semiconductors and, 292 Gilbert, Richard, 234 Glenn Martin Company, 188, 190 Globalization, 130, 469-470, 473 Global News Issues, 440 Goldin, Claudia, 221 Goldman, Henry, 179 Goldman Sachs and Company, 179 Gold Seal Electrical, 196 Gold standard, 130–137 Gommel, Rainer, 153, 136 Gompers, Paul A., 416 Good, David F., 155 Goodyear Tire and Rubber, 201, 231 Gorman, Mel, 47 Government, 2, 28 Air Mail Act and, 185, 192 antitrust policies and, 20, 251, 264, 312n3, 330, 347-348 Bayh-Dole Act and, 311, 472 bond prices and, 45 computers and, 317–319 defense budget and, 283 deflation effects and, 137–158 ERISA and, 470 federal funding and, 283-311 finance capitalism and, 131 financial experiments of 1890s and, 133-137 IBM and, 318–322, 327, 330–334, 337-339 information technology (IT) and, 283 - 311Kelly Act and, 185–186 Liberty Bonds and, 199, 221 McNary Watres Act and, 191–193 New Deal and, 251 patents and, 4-5 Radio Corporation of America and, 193 - 194research and development (R&D) and, 256–257 tax changes and, 168 Victory loans and, 199

Graham, Margaret B. W., 19–20, 247-282, 411 Gramme Electrical Company, 49 Granger causality analysis, 454–457 Grasselli, C. A., 44, 50 Gray, John, 99 Great Britain, 5, 132–133, 156 British Post Office (BPO), 253, 260 - 261British Telecom, 253 computers and, 295 Corning Glass Works and, 265 deflation effects and, 143–153 financial experiments of 1890s in, 133-137 Internet and, 307 radio and, 194 technological lag of, 152–153 Great Crash, 217–218, 241 Great Depression, 166–167 Great Lakes Aircraft, 190 Green, Milford B., 425 Greenwald, Bruce C., 408 Grigsby-Grunow, 196 Griliches, Zvi, 224, 233, 441 Gross, Daniel, 251, 256, 258, 266, 270Gross Domestic Product (GDP) measurement, 17, 169–170, 219, 428 Gross National Product (GNP) measurement, 219, 224 Grossman, Sanford J., 409, 414 Growth airplane industry and, 185–193 Cleveland, Ohio and, 41–75 Detroit, Michigan and, 85–126 financial experiments of 1890s and, 133 - 137intangible capital and, 217-242 Second Industrial Revolution and, 130-133 (see also Second Industrial Revolution) technology and, 2–3 U.S. Stock Market and, 163–172, 178

Grumman, 190 Gründungkrise, 153–155 Guardian Trust Company, 44 Gunnell, John, 91 Gustin, Lawrence D., 117 Halberstam, David, 86 Hall, Robert, 217, 219 H. A. Lozier and Company, 120 Hammack, David C., 42 Hanna, Daniel R., 45 Hanna, Marcus, 44 Hanna, Robert, 44 Hart, Oliver D., 409, 414 Harvard University, 329 Hastings, Charles, 114–115 Hayden, Stone and Company of Boston, 189 Hayes, Rutherford B., 49 Hayes, Webb C., 49 Haynes-Apperson, 105 Hazard, John, 209 Hecht, Jeff, 250, 253, 264 Helfat, C. E., 382 Henry Ford Company, 97–98, 103 Herrick, Myron T., 49, 58 Hicks, D., 367 Hicks, George B., 47 Hinkley, James W., 55 Hirshleifer, David, 436 Hitchcock, Peter M., 54 Hitt, Lorin M., 221–222, 234–235 Hobijn, Bart, 234, 238 Holding companies, 130 Hornblower and Weeks, 181 Houghton, Amo, 259, 267, 269–270, 274 - 275Hounshell, David, 19, 220, 241, 256 Hoyt, Henry I., 49 Hritsko, Rosemary Solovey, 56, 59 Hsu, D., 368, 380, 383 Hudson, J. L., 109–110 Hudson Motor Car Company, 94, 105, 109–110, 121, 125, 177, 181 Hughes, Thomas Parke, x, 12, 56, 59, 153, 157

Hughes Corporation, 301 Hupp, Robert, 114-115, 122 Hupp Motor Car Company, 114–115, 120–121, 123 Hurd, Cuthbert, 326–328 Hydroelectricity, 52 Hyper-text markup language (HTML), 308-309 Hyper-text transfer protocol (HTTP), 308-309 I. C. I., 228 I. G. Farben, 228 ILLIAC, 295 Incandescent lamp, 220 Independent software vendors (ISVs), 302 Industry, 28. See also Specific industry 1920s and, 197-203 development of new, 203-207 federal R&D and, 283-311 information technology (IT) and, 283 - 311intangible capital and, 217-242 post-1920s and, 207-210 secrecy and, 381-382 stock issue effects and, 169-196 technology transactions and, 384-385 (see also Technology transactions) Information and communications technology (ICT), 238-239 Information technology (IT), 22, 130 adoption rates and, 284 airlines and, 283 banking and, 283 computers and, 294-300 federal R&D and, 283-311 Internet and, 283, 305-309 public R&D and, 285-287 railroads and, 283 semiconductor industry and, 283-284, 288-294 software and, 300–305 Ingersoll-Rand, 231-232

Initial public offerings (IPOs), 208 capital raised, 443-444 COMPUSTAT database and, 27 knowledge capital and, 433-454 market indicators for, 443 proceeds from, 451-454 Innovation, x adoption rates and, 284 automobile industry and, 85-126 (see also Automobile industry) commercializing firms and, 12-21 complementary capabilities and, 382-383 debugging and, 284 employee ideas and, 121-122 employment relationship and, 397n1 federal funding and, 283-311 financial experiments of 1890s and, 133 - 137financial markets and, 16-17 globalization and, 469-470, 473 human capital and, 220-221 information technology (IT) and, 283-291 institutional environment for, 2 intangible capital and, 219-221 invention process and, 1 licensing issues and, 262-264 market value and, 233-242 moving assembly line and, 96 networking and, 20-21 patents and, 3-12 as product, 1-2 production methods and, 88, 95–96 Second Industrial Revolution and, 39-75, 130 (see also Second Industrial Revolution) technology transactions and, 366-368, 385-393 Third Industrial Revolution and, 39 U.S. Stock Market and, 163-164 Inside vapor deposition (IV) process, 271 - 272Institute for Advanced Study, 295 Institute of Electrical Engineers, 249

Institutional Change and American Economic Growth (Davis and North), xi Institutions automobile industry and, 85-126 commercializing firms and, 12-21 deflation effects and, 137–158 early U.S. framework of, 3-12 globalization and, 469-470, 473 IPOs and, 27 knowledge capital and, 433-463 limited role of financial, 56–58 market forces and, 23-27 mergers and, 54-55 networking and, 20-21 patents and, 3–12 Second Industrial Revolution and, 13 - 15spin-offs and, 104–126 start-ups and, 15–17 survival curves and, 92-94 Insull, 140 Intangible capital 1920s and, 239 AT&T and, 228, 230, 232 company financials and, 222-224 Eastman Kodak and, 222, 230, 232 E. I. Du Pont and, 222, 228, 230, 232 estimating market value of, 233-242 General Electric and, 220, 222, 228, 230, 232, 241 General Motors and, 221–222, 231-232 human capital and, 220-221 information and communications technology and, 238-239 innovation and, 219-221 new technologies and, 237-241 NYSE and, 237–238 patents and, 218–232 research and development (R&D) and, 220, 222 Westinghouse and, 224, 228, 232 Integrated circuits, 292-293

Intel, 241, 348 Intellectual property, 248 complementary assets and, 374-375 patents and, 3–12 (see also Patents) returns from protecting, 285-286 Interchangeable parts, 100 Interface message processor (IMP), 305 - 306International Business Machines (IBM), 19, 23, 207, 313n9, 317, 471 305 RAMAC and, 335, 354n52 603 Electronic Multiplier and, 326, 328, 330 604 Electronic Multiplier and, 326-328, 330 650 drum computer and, 335, 337 701 and, 320-322, 331, 338-339, 353n36 702 and, 321, 338 704 and, 335 705 and, 331, 333, 335, 339 antitrust policies and, 330, 347–348 business practices of, 322-325, 343-348 card-programmed calculator (CPC) and, 326–330 commercial success of, 334-338 debts of, 332 enters electronic data processing, 325-330 government contracts and, 318–322, 327, 330-334, 337-339 Internet and, 306 lost initiative of, 330-331 punched cards and, 322-324 rental agreements and, 323, 350n14 research and development (R&D) and, 318-319 SAGE system and, 319–322, 331–333, 337, 339–340, 344, 348 SNA and, 306 software industry and, 300-301 solid-state design investment and, 338-343, 358n79, 360n84

International Business Machines (IBM) (cont.) STRETCH and, 337 System/360 and, 317-320, 338, 341, 343, 345, 347-348, 362n102 Texas Instruments and, 341–342, 347, 358n77 Watson and, 320–321 International Motors, 180 Internet, 22, 283 federal R&D and, 305-309 IBM and, 306 Inventors, 1. See also Specific person Brush Electric Company and, 50–56 commercializing firms and, 12-21 Crystal Palace exhibition and, 3, 471 employee ideas and, 53-54 as financial information sources, 46 - 61networking and, 50-56 patents and, 3-12 Second Industrial Revolution and, 13 - 15, 28specialization and, 6-7 start-ups and, 15–16 United States and, 2 Inventory, 224 Investment, 18–19 automobile industry and, 175-182 commercializing firms and, 12-21 con artists and, 49 deflation effects and, 137-158 demonstration effect and, 47-50 early-stage backing and, 40-41 entrepreneurs and, 405–429 financial information and, 46-61, 131-132 going public and, 45–46 government's role and, 2, 21–23 IBM and, 330–344 information sources and, 46–61 institutional framework and, 3-12 intangible capital and, 217-242 IPOs and, 27 mistakes in, 49 patents and, 3-12

Second Industrial Revolution and, 13 - 15, 28technological advancement and, 1 (see also Technology) U.S. Stock Market and, 163–211 (see also U.S. Stock Market) IPO Reporter, 440 Iron, 42, 45, 132 Israel, 470 Israel, Paul, 46 Italy, 265 ITT, 253, 262, 268 Jackson, Roscoe, 107–109, 122–123 Jaffe, Adam, 224 Janeway, William, ix-xii Japan, 369 Corning Glass Works and, 265, 270 entrepreneurs and, 411 semiconductors and, 292 Jensen, Michael C., 408 Jewett, Harry, 119 J. I. Case Threshing Machine Company, 227 Jin, Hechui, xi JOHNIAC, 295 Johnson, Thomas H., 257 Joint development agreements (JDAs), 265-266, 269 Joint ventures automobile industry and, 88, 106–107, 114 Corning "associations" and, 19-20, 250-251 in research and development, 341, 367, 369, 437-438, 447, 454 Sperry Electric Railway and, 56 Jones, Lyle V., 442 Joseph Henry (trolley car), 52 Jovanovic, Boyan, 170, 234, 238 J. & W. Seligman, 178 Kaffir shares, 144 Kahn, Robert, 306 Kalachek, Edward D., x

Kamien, Morton, 411

Kantrow, Alan M., 95–96, 98, 100, 102, 105, 110, 115–116, 124 Kao, Charles, 262, 268 Kaplan, Robert S., 257, 426 Kaufman, Louis, 178 Keck, Donald, 260 Kelly, Mervin, 288–289, 324, 339-343 Kelly Act, 186 Kelly Bill, 185 Kennedy, J. H., 47 Kenney, Martin, 257 Kettering, Charles, 183 Keys, Clement M., 185–186, 189 Khan, Zorina, 1, 3, 5, 7, 12, 227 Khanna, T., 367–368, 387 Kilby, Jack, 290 Kim, J., 367 Kimes, Beverly R., 91, 112, 116, 118 King, Charles, 105–106 Kleiman, H., 290 Kleinrock, Leonard, 305 Kleinwort Sons & Company, 179 Klepper, Steven, 14-17, 41, 175, automobile industry and, 85-128 patents and, 383, 392 stock market swings and, 221, 238-239 Kline, S. J., 366 Knight, Walter H., 51, 57 Knowledge capital, 463 biotechnology and, 441–442 COMPUSTAT database and, 27 financial variables and, 444-446 Granger causality analysis and, 454-457 IPO analysis and, 433–454 measurement of, 444-446 natural excludability and, 434-436 patents and, 441, 445 spillovers and, 441–442 stock price behavior and, 444, 457-462 study data for, 437–446 theoretical approach to, 434–437 Kogut, B., 366, 374

Kollins, Michael J., 96–97, 99, 115 - 116Kolster Radio Corp., 196 Korean War, 319, 331 Kortum, Samuel, 24, 470 Kundtz, Theodor, 44, 59, 80n40 Kurz, Mordecai, xi Kuznets, Simon, ix-x Labor, 28-29, 365 Brush Electric Company and, 53 ERISA and, 470 human capital and, 220–221 knowledge capital and, 437-448 Lake Superior, 42 Lamoreaux, Naomi R., xi, 248, 408, 469-474 historical innovation financing and, 1 - 37intangible capital and, 220 patents and, 366, 368, 380 Second Industrial Revolution and, 39 - 84U.S. Stock Market and, 205 Landau, Ralph, 153 Lange, J. R., 207 Langlois, R. N., 301, 303 Langmuir, Irving, 220 Lasers, 253, 260 Lawrence, Washington, 49, 56–57 Lazonick, W., 191 Learson, T. Vincent, 341 Lee, Higginson and Co. of Boston, 178Leffler, G., 201 Legal issues, 7–8. See also Patents antitrust policies and, 251, 264, 312n3, 330, 347-348 Corning Glass Works and, 266–269 financial experiments of 1890s and, 135 - 136patents and, 3-12 Leggett, Mortimer D., 47-48 Lehman, Arthur, 179 Lehman, H. H., 179 Lehn, Kenneth, 413

Leland, Henry automobile industry and, 96–103, 111, 121–123 Lincoln Motor Company and, 112 - 113Leland and Faulconer, 96, 103, 111 Lerner, Joshua, 24, 26, 228, 405-432, 470 Levenstein, Margaret, 14-15, 17, 39-84, 408 Levin, Richard C., 368, 380 Levine, Ross, 170 Levinthal, D. A., 373, 384 Liberty Bonds, 199, 221 Lincoln, John C., 53-54 Lincoln Electric Company, 53–54 Lincoln Laboratories, 297 Lincoln Motor Company, 112–113 Lincoln Motor Works, 54 Lindbergh, Charles, 17–18, 186–187 Linde Air Products Company, 49–50, 57 Lindenberg, E., 222 Lindzey, Gardner, 442 Lipartito, Ken, 252 Liquidity, 170 Liquified air, 49–50 Little, Big Bill, 117–118 Little Motor Company, 117–118 Liu, Qiao, 436, 457–458, 462–463 Loans, 44-45 Lockheed Aircraft, 190, 192 Locomobile Co. of America, 94, 119 Loening, 190 London Stock Exchange (LSE), 155 arbitrage trades and, 148-149 Committee for General Purposes and, 144–147, 149 deflation effects and, 143–153 kaffir shares and, 144 NYSE and, 148–153 World War I and, 149 Loose coupling, 132 Los Alamos National Laboratories, 297 Lozier, H. A., 120

Lucent Technologies, 273 Lucy, Chuck, 261–262, 265 Ma, Tongshu, 155 MacAvoy, Tom, 259, 267, 275 MacGarvie, 220 Machine tool industry, 42 Maclaurin, W. Rupert, 193–194, 204 Maddison, Angus, 169 Majluf, Nicholas S., 408 Malaysia, 426 Malcolmson, Alexander, 99, 176 Mancke, Richard B., 297–298 MANIAC, 295 Mansfield, E., 368 Manufacturing automobile industry and, 85-126 Cleveland, Ohio and, 41-75 fiber-optic technology and, 248 interchangeable parts and, 100 moving assembly line and, 96 precision, 96-97, 113-114 production methods and, 88, 95–100 U.S. Stock Market and, 173-196 Marconi company, 193 Markets. See also U.S. Stock Market building capacity in advance of, 270 - 272clearing mechanisms and, 140 Cleveland, Ohio and, 45–75 computers and, 317-318, 330-331 (see also Computers) deep capital, 132 deflation effects and, 137-158 entrepreneurs and, 408 equity, 45 financial experiments of 1890s and, 133 - 137financial information and, 46–61, 131 - 132fixed-capital, 175–176 futures, 130 global, 130, 469-470, 473 innovation in, 16–17 intangible capital and, 217-242 knowledge capital and, 433-463

liquid, 132 New York Stock Exchange and, 141-142 (see also New York Stock Exchange (NYSE)) over-the-counter (OTC), 202-203, 209-210 patents and, 3–12 returning forces of, 23-27 Second Industrial Revolution and, 130-133 (see also Second Industrial Revolution) securities, 17, 40 software, 302–305 start-ups and, 24-25 technology transactions and, 368–370 (see also Technology transactions) World War I and, 155–157 Marschke, G., 367 Martin Company, 183 Marx, Leo, x Maskus, K., 369 Mason, Arthur, 117–118 Mason Motor Company, 117–118 Massachusetts Institute of Technology (MIT), 297, 305, 319, 331, 368 Matthiessen, Frederick William, 52, 79n27 Mauchly, John W., 295, 330 Mauchly, William, 329 Maurer, Robert, 249, 260-262, 266 - 267Maxwell, Jonathan, 104-106, 121–122, 124, 179–180 Maxwell-Briscoe Motor Company, 104–106, 120–125 Maxwell Motor Company, 120, 178 May, George S., 95–97 McCormick, 142 McDowell, Wallace, 329–330 McGrattan, Ellen R., 218–219 MCI, 254, 268, 272, 275 McKie, James W., 297-298 McNary-Watres Act, 191–193 Meckling, William H., 408 Mees, Kenneth, 220

Menasco Manufacturing, 192 Merck, 471 Mergers, 54–55, 101–102, 114, 184 Merges, Robert, 26, 380 Merton, Robert C., 405 Metzger, William, 98, 105, 113-114, 121 - 124Mezzanine finance, 142 Michelsen, Al, 267 Michie, Ronald C., 136, 144, 148, 155 Microsoft, 237–238 Milgrom, P., 374 Miller, Carol Poh, 42 Miller, Merton, 413 Miller, Stewart, 250 Miranti, Paul, 168 Missile systems, 290 MITRE Corporation, 301 Mokyr, Joel, 228 Montgomery Ward, 201 Monumental Park, 48 Moody's Manual of Industrial Securities, 61, 180, 222, 227, 440 Moore, John, 409 Moore School, 295 Morck, R., 169 Morgan, E. V., 148 Morgan, J. P., 16, 106, 122 Morone, Joseph G., 266 Mosaic, 308-309 Moser, Petra, 227 Motolese, Maurizio, xi Moving assembly line, 96, 100 Mowery, David C., 2, 21, 366, 373 federal funding and, 283-316 stock market and, 220, 228 Munn and Company, 7–8 Murphy, Edward, 112 Myers, Stewart C., 408 Nagaoka, S., 369 NASA, 300 Nasdaq, 210, 237–238 Nash Motors Company, 177 National Academy of Science, 317, 442

National Air Transport, 186 National Battery Company, 56 National Carbon Company, 45, 49-50, 56-58 National Cash Register Company, 108-110, 124, 183, 322, 333-334 National Center for Supercomputing Applications, 308 National City Bank of New York, 189 National City Company, 189 National Institutes of Health (NIH), 21 National Research Council, 61, 220, 298-299, 306 National Science Foundation, 307-308, 314n16, 398n13 National Security Agency, 98, 297 Navin, T., 211n1 Neal, Larry, 16–17, 129–161, 408 Nelson, Emil, 114 Nelson, Richard, x, 21, 86 federal funding and, 285-286, 309, 311 Second Industrial Revolution and, 157 - 158stock market and, 228 technology transactions and, 365, 368, 376, 380, 383 Neon lights, 129 Neoprene, 220 Nerkar, A., 382 Net present value (NPV), 257 Networking Brush Electric Company and, 50-56 Buick and, 101 Durant and, 101–102 General Motors and, 101-102 software and, 304-305 Nevins, Allan, 99 Newbery, David, 234 New Deal, 251, 264 New York Curb market, 18 Second Industrial Revolution and, 141 - 142U.S. Stock Market and, 179–180, 184, 188, 194, 201-202

New York Stock Exchange (NYSE), 16-18, 40, 45, 200-201 automobile industry and, 179–180 as blue chip market, 140-141 clearing mechanisms and, 140 Consolidated and, 140-141 deflation effects and, 137-143 financial experiments of 1890s and, 135 - 137intangible capital and, 237-238 London Stock Exchange and, 148 - 153panics of 1890/1893 and, 140 quality imprimatur and, 141-142 seat prices and, 142-143 Second Industrial Revolution and, 130, 156, 158 New York Times, 48, 179 Niagara Falls, 52 Nicholas, Thomas, 18-19, 217-245 Nobel Prize, 220 Nohria, Nitin, 252 Nonlinear technologies, 132 North, Douglas C., xi-xii North American Group, 190–192 Northern Manufacturing Company, 105 - 106, 121Northrop Aircraft, 297 Northrup Aviation, 327 NSFNET, 308 Nylon, 220 Oakland Motor Car Company, 112, 122 Office of Electronic Information Products and Services, 441 Official Gazette, 237 Ohio Auto Co., 89 Ohio National Bank, 44 Olds, P. F., 95 Olds, Ransom Brush and, 111 business practices of, 95–97, 102–103, 106–107, 122–123

Olds Gasoline Engine Works, 107

Olds Motor Works, 102, 125 automobile industry organization and, 88-89, 94-97, 103-104, 108, 177 E. R. Thomas-Detroit and, 107–109 Hudson Motor Car Company and, 109 - 110Maxwell-Briscoe and, 104-106 Reo Car Company and, 106–107 Saxon Motor Company and, 110-111 spin-offs and, 105-111 subcontractors and, 103–104 Open Standard Interconnect (OSI), 306 Optical transmission, 20 ORACLE, 295 Ordinary least squares (OLS) analysis, 235, 386 Organization for Economic Cooperation and Development (OECD), 367 O'Sullivan, Mary, 17–18, 163–216, 221, 241, 408 Otis Elevator, 224 Outside vapor deposition (OV) process, 271-272 Owens, Raymond, 107 Owens-Corning, 251 Pacific Aero Products, 183 Packard Motor Car Company, 89, 120, 177 Packet switching, 305-306 Paige, Fred, 119 Paige-Detroit Motor Company, 119, 180Palmer, Ralph, 326-328, 339-341 Parente, Stephen, 219 Passer, Harold C., 14, 19 Pástor, Lubos, 237–238 Patents, 22, 25, 55–56, 61, 274, 471 AT&T and, 252–253, 261 banks and, 6 Bayh-Dole Act and, 311, 472 Cleveland, Ohio and, 39-40, 42

company financials and, 222–224 complementary assets and, 374-375, 383 conflicts in, 50 Corning Glass Works and, 266–269 disputes over, 52 expanded commerce from, 7–8 fee for, 4 fiber-optic technology and, 266-269 filing costs and, 4–5 funding and, 4-5 government and, 4–5 historical perspective on, 221–232 increase of, 7-9 infringement issues and, 266-269 intangible capital and, 218–232 investment incentives and, 4-5 knowledge capital and, 441, 445 lawyers and, 7–8, 12 multinational licensing and, 369 profits from, 5-8 protection effectiveness of, 380-381 radio and, 193–194 reform of 1836 and, 7-9, 30n5 regional data of, 10-12 registration system and, 4–5 royalties and, 48 Scientific American and, 7–8 Second Industrial Revolution and, 14 - 15secrecy and, 381-382 shares in, 6-7 specialization and, 6-10 technology transactions and, 368 - 374telecommunications and, 261 transfer of rights and, 6-10 uniform laws for, 367 U.S. lead in, 3–12, 31n8 validation of, 4 wildcatters and, 49 Patent Technology Set: Genetic Engineering, 441 Patterson, John, 322 Peach, 221 Peck, Merton J., x

Peerless, 180 People's Savings and Loan Association, 44 Perez, Carlota, x, xii, 130–131 Perrow, Charles, 132 Petroleum, 130 P. F. Olds & Son, 95 Pharmaceuticals, 385 Phelps, Byron, 326–328 Philadelphia, 18 Philippines, 426 Photography, 220 Pierce-Arrow, 180 Piore, Emmanuel, 340, 357n71 Pittsburgh, 251 Pittsburgh Reduction Company, 52 Plastics, 129 Pontiac Buggy Company, 112 Poor's, 61, 181 Pope Manufacturing Co., 94 Poulson, Annette B., 413 Pratt and Whitney Aircraft Corporation, 186, 189, 192 Precision tools, 14 Prentiss, John, 181–182 Prescott, Edward C., 218–219 Princeton University, 295 Production aircraft industry and, 190-191 capacity building and, 270-272 creativity and, 248-249 Ford and, 99-100 innovations in, 88, 95-96, 100 interchangeable parts and, 100 parts contracts and, 108–109 subcontractors and, 103–104 Taylorism and, 241 U.S. Stock Market and, 170, 173 - 175Project Whirlwind, 319 Prudential, 324, 330, 332 Prussia, 155 Public utilities, 173 Punched cards, 322–324 Puttitanum, T., 369 Pyrex, 254

Quaker Oats, 227 Radar, 290 Radio, 17, 18, 129 U.S. Stock Market and, 164–165, 193 - 200Radio Corporation of America (RCA), 237, 289 computers and, 297, 318, 324 IBM and, 324, 340 telecommunications and, 255-256 U.S. Stock Market and, 193-196 Rae, John B., 182–183 Raff, Daniel M. G., 248 Railroads, 13, 16–17, 130 Cleveland Stock Exchange and, 45 deflation effects and, 137-140 information technology (IT) and, 283 streetcars and, 51 U.S. Stock Market and, 166 Rajan, Raghuram, 171, 221 RAMAC (Random Access Memory Accounting Calculator), 335, 354n52 RAND Corporation, 301, 305 Rappoport, Peter, 217–218 Raytheon, 289, 297 rDNA technology, 441-442, 446-447, 450-451 Real estate, 173 Reconstruction Finance Corporation, 192 Recursion analysis, 222, 224 Regression analysis, 169, 235 Reich, Leonard, 252 Reliance Electric, 54 Reliance Motor Car Co., 119 Remington Rand, 295–296 Renner, Gail K., 108, 110 Rentschler, Frederick B., 186, 189 Rentschler, Gordon, 186, 189 Reo Motor Car Company, 106–107, 123, 177 Research and development (R&D), 2, 29, 471-472 adoption rates and, 284

AT&T and, 252–253 biotechnology and, 417-425 commercializing firms and, 12-21 COMPUSTAT database and, 27 control processes for, 258-259 Corning Glass Works and, 248-249, 255-259 division of labor and, 372 documentation and, 266-267 economics of public, 285-287 entrepreneurs and, 414, 417–425 ex ante contracting and, 366 ex post contracting and, 366 federal, 21-23, 256-257, 283-311 fiber-optic technology and, 248-249, 253 - 254firm size and, 372 globalization and, 469-470 IBM and, 318-319 increased costs of, 366-367 industrialization and, 28 information technology (IT) and, 22, 283 - 311intangible capital and, 220, 222 integration of, 367 knowledge capital and, 433–463 lasers and, 260 Lawrence and, 49 market forces and, 23–27 networking and, 20-21 outsourcing of, 371-372 patents and, 9-10, 369-370 (see also Patents) post-World War II era and, 256 proprietary knowledge and, 251-252 resource allocation and, 257 Second Industrial Revolution and, 13-15, 28, 74 (see also Second Industrial Revolution) secrecy and, 381-382 technology transactions and, 368-370, 385-393 U.S. military and, 256–257 U.S. Stock Market and, 171 RFTA (request for technical assistance), 259, 261

R. G. Dun & Company, 50 Rhee, C., 234 Roberts, J., 374 Roberts, P. W., 382 Rockefeller, John D., 77n16 Roedel, J. R., 207 Rollin Motor Company, 60 Romanelli, Elaine, 437, 442 Roosevelt, Franklin, 251 Rose, William Gansom, 59 Rosenberg, Nathan, x, 2–3, 21, 153, 284, 366, 373 Ross, Steven, 222 Royalties. See Patents Runabouts automobile industry organization and, 95–102, 105–108, 113, 125 Brush Runabout Company and, 111 - 112Hupp and, 115 S&P Composite Index, 217 Sahlman, William, 206–207, 415 Savings-and-loan associations, 44 Saxenian, AnnaLee, 1 Saxon Motor Company, 110–111, 124, 180 Schall, L. D., 257 Scheinkman, Jose A., xi

Scherer, F. M., 368

- Schmookler, Jacob, 1
- Schoar, Antoinette, 26, 428 Schumpeter, Joseph, x, 130, 221, 247, 276–277

Schwarzchild, Otto P., 189

Science, 14. *See also* Research and development (R&D) knowledge capital and, 437–446

universities and, 220-221

Scientific American, 7–8, 32n11, 129, 237

Scotchmer, Suzanne, 224

Scott, Richard, 107

Sears, 211n1

Second Industrial Revolution, 13–15, 28

Second Industrial Revolution (cont.) banks and, 131 Brush Electric Company and, 47–56 deflation effects and, 137-158 Federal Reserve System and, 131 finance capitalism and, 129-158 financial information sources and, 46-61, 131-132 institutional financing and, 39 modern effects of, 129 NYSE and, 40 quantitative patterns in, 61-73 research and development (R&D) and, 39 White Sewing Machine Company and, 58–61 Secrecy, 381-382 Securities, 45 clearing mechanisms and, 140 deflation effects and, 137–158 financial experiments of 1890s and, 133 - 137Securities and Exchange Commission (SEC), 202, 208-209, 211n2 Securities Data Company, 440 Seltzer, Lawrence, 175–176, 178, 180 SEMATECH, 312n6 Semi-Automatic Ground Environment (SAGE) air defense network federal funding and, 297, 301 IBM and, 319–322, 331–333, 337-340, 344, 348 Semiconductors, 22 federal R&D and, 288-294 IBM and, 338–343 information technology (IT) and, 283 transistors and, 228-290, 338-343 Severance, J. L., 50 Shane, S., 383 Sheppard, Samuel, 220 Sherbloom, James P., 421 Shettler, Reuben, 106–107, 122 Shiller, Robert, 217 Shleifer, Andrei, 169, 217, 415 Shockley Laboratories, 290 Short, Sidney H., 15, 52-53, 55, 57

Short Electric Railway Company, 53 Shuldiner, Alec T., 251, 256, 259, 261, 264, 266–267, 270 Siecor, Inc., 269–270 Siemens, 266, 269 Signetics, 263 Sikorsky Aircraft, 192 Silicon Valley, 1 Simcoe, 306 Simmons, Kenneth, 221 Simplex Automobile Company, 183 Singh, Ajai, 446 Sloan, Alfred P., 19 Small Business Innovation Research (SBIR), 442, 450, 452 Smelting processes, 51–52 Smil, Vaclav, 129 Smith, Adam, 365 Smith, Fred, 95 Smith, John Kenly, Jr., 19, 220 Smith, Merritt Roe, x Smith, Philip H., 87, 91, 175 Smith, P. J., 369 Smith, Samuel, 95, 102, 106, 108 Smith, S. Winifred, 53 Snowden, Kenneth, 137–138 Sobel, Robert, 140, 201, 207-208, 323 Social Science Research Council (SSRC), xi Society for Savings, 42, 49, 58 Soete, Luc, x Software industry, 22, 300–305 Sokoloff, Kenneth L., xi, 408, 469-474 historical innovation financing and, 1 - 37patents and, 366, 368, 380 Second Industrial Revolution and, 39 - 84U.S. Stock Market and, 227 South Korea, 426 Soviet Union, 208, 295 Specialization, 6–10 Sperry, Elmer, 12, 15, 53, 56, 59, 77n16

- Sperry Electric Railway Company, 56 Sperry Rand, 295–296 Sperry Syndicate, 56, 58 Spillovers, 441–442 Sputnik, 208 Standard Catalog of American Cars, The, 91 Standard Communications Laboratory (SCL), 253 Standard Oil, 50, 142, 228 Stanford University, 442 Star car, 118-119 Start-ups, 15–17. See also Cleveland, Ohio; Detroit, Michigan going public and, 45–46 market forces and, 24–25 Steam power, 130 Steel, 13–14, 42, 100, 115–116, 132 Stephan, Paula E., 436–437 Stern, Scott, 1, 368, 380, 383 Stevenson, Howard, 206–207, 415 Stiglitz, Joseph E., 408–409 Stock Exchange Official Intelligence, The (Burdett), 149 Stockly, George W., 47–48, 51, 57 "Stock Market and Investment, The: Is the Market a Sidewhow?" (Morck, Shleifer, and Vishny), 169 Stocks. See also U.S. Stock Market Britain and, 143–153 clearing mechanisms and, 140 deflation effects and, 137-158 financial experiments of 1890s and, 133-137 Germany and, 153–155 Stock tickers, 46 Streetcars, 45, 51-53, 55 Strojwas, Marcin, 228 Stromberg, Per, 426 Studebaker Brothers Manufacturing Company, 178–179 Studebaker Corporation, 113–114, 178 - 180Sturtevant Aeroplane, 184 Stutz, 180
- Subcontracting, 96-97, 103-104

Sudzarek, Robert G., 97–99, 111-116, 119 Sumitomo, 268 Summers, Lawrence, 234 Sundem, G. L., 257 Superior Cable, 270 Survival curves, 92–94 Swan Lamp Manufacturing Company, 54 Sylvania, 289 Synthetic fertilizers, 129 Systems Development Corporation (SDC), 301–302 Taiwan, 426 Tauman, Yair, 411 Taxes, 168, 251 Taylorist approach, 241 TCP/IP protocol, 306–308 Technological Revolutions and Financial Capital (Perez), xii Technology, x automobiles and, 85–126 (see also Automobiles) biotechnology, 27, 434, 438, 441–442, 446–447, 450–451 commercializing firms and, 12-21 computers and, 317-318 (see also Computers) Crystal Palace exhibition and, 3, 471 DNA, 27 evaluation of, 18–19, 27 financial information and, 46-61, 131-132 funding of, 1–2 government role and, 2 intangible capital and, 237-241 IT, 130, 283–311 (see also Information technology (IT)) knowledge capital and, 433-463 long-run economic growth and, 2–3 nonlinear, 132 optical fiber and, 247-277 patents and, 3-12, 369-370 (see also Patents) process technologies and, 260

Technology (cont.) radio and, 193–196 rDNA, 441-442, 446-447, 450-451 Second Industrial Revolution and, 13-15, 39-75 spacecraft and, 208 specialization and, 6–10 transforming effects of, 129 universities and, 220-221 Technology transactions absorptive capacity and, 384 complementary assets and, 374–375, 382-383 cost and, 373-374 empirical analysis results for, 385-396 ex ante, 366, 377-378 ex post, 366, 368–370, 376, 378 extent of, 378-380 firm size and, 372, 383 gains from trade and, 372 industry characteristics and, 384-385 knowledge codification and, 384 measures for, 376-380 rivals and, 383-384 secrecy effectiveness and, 381-382 transfer costs and, 373-374 Teece, David J., 382 Telecommunications, 238 AT&T monopoly of, 252–253 cable and, 269-270 information technology (IT) and, 283–291 line capacity issues and, 252-253 patents in, 261 radio and, 193–196 telegraphs and, 13, 47–48 telephones and, 13, 52 U.S. Stock Market and, 193–196 Telegraphs, 13, 47–48 Telegraph Supply Company of Cleveland, 47-48. See also Brush Electric Company Telephones, 13, 52

Television, 255–256, 273 Temin, Peter, 248, 252 Tesla, Nikola, 129 Texas Instruments, 290, 293, 318, 341-342, 347, 358n77 Third Industrial Revolution, 39 Thomas, E. R., 108–109, 122 Thomas, Horace, 107 Thomas, W. A., 148 Thomas-Detroit, 108–109 Thomas Register, 183-184 Thomson, Elihu, 14 Thomson Houston Electric Company, 48, 51, 55–56 Tight coupling, 132 Tilton, J., 289–290 Tirole, J., 228, 414, 436 Tobin's *q*, 224 Tractors, 60, 129 Tracy, James J., 47–48, 58 Trajtenberg, M., 372 Transcontinental Air, 192 Transistors. See Semiconductors Transitron, 290 Tripsas, M., 382 "Trunk Telecommunications by Guided Waves" (Institute of Electrical Engineers), 249 Trust companies, 42, 44, 130 TRW, 301 Tufano, Peter, 413 Twentieth Century Fund, 201–202 Union Carbide and Carbon Company, 50, 52 Union National Bank, 44 Union Pacific Railroad, 138 United Aircraft and Transport Corporation, 189–190, 192 United Airlines, 192 United States antitrust policies and, 264 Asian contracts and, 425–428 automobile industry and, 85–126 Bayh-Dole Act and, 311, 472 biotechnology and, 417-425

Cleveland, Ohio, 39–75 Constitution of, 4 Crystal Palace exhibition and, 3, 471 defense budget and, 283 deflation effects and, 137-143 Detroit, Michigan, 85-126 early institutional framework of, 3 - 12economic history of, 27-28 federal funding and, 283-311 Federal Reserve System and, 131 financial experiments of 1890s in, 133 - 137globalization and, 469-470, 473 high rate of invention in, 2 information technology (IT) sector and, 283-311 New Deal and, 251, 264 patent system of, 3–12, 31n8 population data of, 11-12 Second Industrial Revolution and, 13-15, 28, 39-75, 130-133 Third Industrial Revolution and, 39 United States Motor Company, 178 United States Steel, 238–239 Universities, 220–221 computer research and, 294–295 federal R&D and, 287, 294-295 University of California, 442 University of Denver, 52 University of Illinois, 308 University of Michigan, 107 University of Pennsylvania, 295 Unix to Unix Copy protocol (UUCP), 306 U.S. Air Force, 319–322 U.S. Bureau of Economic Analysis, 442 U.S. Census Bureau, 42, 174–175, 184 - 185U.S. Department of Commerce, 442 U.S. Department of Defense, 21 DARPA and, 305–306, 307 federal funding and, 289, 294, 297 Internet and, 305–309 software industry and, 300-305

U.S. Department of Justice, 264-265, 347 U.S. military, 185, 191, 193, 331 computer research and, 294–300 IBM and, 318-322 SAGE system and, 297, 301, 319-322, 332–333, 337–340, 344, 348 semiconductors and, 288-294, 290 telecommunications and, 256-257, 268 U.S. Motors, 112, 114, 120 U.S. Patent and Trademark Office (USPTO), 441, 472 historical innovation financing and, 6, 8, 30n4, 31n10 intangible capital and, 218–219, 224, 227–228, 237 Second Industrial Revolution and, 51 U.S. Post Office, 185, 188, 191–193 Usselman, Steven W., 23, 317–363 U.S. Stock Market, 163 1920s and, 164-165, 172-175, 197–203, 210–211, 217–219, 239 aircraft industry and, 182-193, 197, 199 automobile industry and, 164, 175 - 182aviation industry and, 164-165 descriptive statistics for, 224–227 financing role of, 166–169 Great Crash and, 217-218, 241 Great Depression and, 166–167 historical financing trends and, 166-169 industry development and, 172–196 intangible capital and, 217–242 liquidity and, 170 manufacturing and, 173–196 Nasdaq and, 210 new industry development and, 203 - 207NYSE and, 137–143, 179 (see also New York Stock Exchange (NYSE)) over-the-counter (OTC) market and, 202-203, 209-210 overvaluation and, 218-221

U.S. Stock Market (cont.) post-1920s and, 207-210 public utilities sector and, 173 radio and, 164–165, 193–200 railroads and, 166 real estate and, 173 regression analysis of, 169 research and development (R&D) and, 171 S&P Composite Index and, 217 Securities and Exchange Commission (SEC) and, 202, 208–209, 211n2 stock issues effects and, 169–196 tax changes and, 168 time function and, 218-219 U.S. economy and, 169–172 World War II and, 207 U.S. Treasury, 198 Vanadium, 100 van der Linden, Robert F., 186, 188, 191 Vander Meulen, Jacob A., 191 van Horne, James C., 413 Venture capital, ix–xi, 26, 471–472 Asian contracts and, 425–428 automobile industry and, 97-98 (see also Automobile industry) Cleveland, Ohio and, 44–45 con artists and, 49 demonstration effects and, 47-48 early-stage backing and, 40-41 entrepreneurs and, 405-429 financial information and, 46–61, 131 - 132going public and, 45–46 Granger causality analysis and, 454-457 information sources and, 46-61 J. P. Morgan and, 106, 122 NYSE and, 16–18 private equity and, 427 Second Industrial Revolution and, 13-15, 28, 39-40start-ups and, 15–16 U.S. Stock Market and, 206–207

VentureXpert, 444 VentureOne, 416 Veronesi, Pietro, 237–238 Very High Speed Integrated Circuit (VHSIC) program, 294 Veugelers, R., 369 Victory loans, 199 Vishny, R., 169 von Hippel, E., 366 Vonk, Gerro, 425 von Linde, Carl, 49–50 von Neumann, John, 295, 300 Vulture capitalists, 405 Wade, Jeptha, 45 Wager, Richard, 56, 59 Walker Manufacturing Company, 54-55, 57 Wall Street Journal, 186–187, 195 Walsh, J. P., 228, 368, 376, 380, 383 Warburg, Pincus, x Warner and Swasey, 58 Watson, Katherine, 144 Watson, Thomas, Jr., 320–321, 327-332, 338-344 Watson, Thomas, Sr., 322, 324–325, 329-331, 334 Weisberger, Bernard A., 117–118 Weiss, Andrew, 408–409 Weitzman, Martin L., xi Welch, Ivo, 417, 436 Wellman-Seaver-Morgan, 45 Western Air, 192 Western Electric, 249, 263 Western Union, 46 Westinghouse, 19, 55, 194, 224, 228, 232 Wheeler, Robert, 42 Wheels of Commerce, The (Braudel), ix White, Clarence, 60 White, Eugene N., 134, 217–218, 221 White, Howard W., 58 White, Rollin C., 55–56, 58–59 White, Rollin H., 59–60, 81n43 White, Thomas H., 58–60, 81n43

White Sewing Machine Company, 45, 55-62 Whiting, James, 100, 102–103 Wildcat companies, 49 Williams, Albert, 332, 343 Willson, Thomas L., 52 Willys-Overland Company, 121, 177, 179-180 Wilson, John Grosvenor, 140 Wilson, Lee, 267–268 Winkelbörsen, 154 Winter, S. G., 366, 374 Wise, George, 19 Wong, Kwei Cheong, 425 Woodland Avenue Savings and Trust, 44 World War I era, 181, 221 automobile industry and, 98 Second Industrial Revolution and, 134-135, 149, 155-157 World War II era, 22, 151, 207 computers and, 317-318, 329 Corning Glass Works and, 255-256 IBM and, 330, 332 research and development (R&D) and, 256 World Wide Web, 305, 317 Wright, Brian D., 411 Wright Aeronautical Corporation, 183-188 Wright brothers, 182 Wright-Martin Aircraft Corporation, 183 Wu, G., 207 X.25, 306 Xiong, Wei, xi Yang, G., 369 Yang, Shinkyu, 222, 234–235 Yanik, Anthony J., 105–106 Zander, U., 366, 374

Zingales, Luigi, 170–171, 221 Zucker, Lynne G., 26–27, 433–467 Zuniga, M. P., 369

Zeira, Joseph, 241 Zervos, Sara, 170 Ziedonis, A. A., 367