Index

Anand, B. N., 186 Antitrust policy guidelines for markets in goods, technology, and innovation, 5 proposed change in patent-pooling agreements, 268-270 Application Specific Integrated Circuits (ASICs), 66-67 computer-aided-design (CAD), 153 new ASIC architecture, 107-108 separate manufacture and design of, 153 traditional development of, 107 Armstrong, J., 28–29, 43, 199 Arora, A., 46, 53, 98-99, 123, 124, 157, 164, 186,234 Arrow, K. J., 1, 93, 124-125 Balcet, G., 128 Baldwin, C. Y., 103, 104–105 Barney, J. B., 226 Bayh-Dole Act (1980), 270-271 Bell, M., 128, 136 Biotechnology chemistry used in, 70-71 drug discovery and research tools, 70 information technology uses in, 70-74 as research tool, 65 semiconductor technology applications, 74 Biotechnology industry dedicated biotechnology firms (DBFs) in, 63-65, 71-75 development of (1970-80), 63-65 equity financing for firms in, 67, 70 general purpose tools in, 160-163 growth (1990s), 65-70

industry structure and use of GPTs in, 160-163 platform and product-specific firms in, 160-162 platform companies, 160-163 product-specific, 160-163 robotic techniques used in, 71 technological alliances in, 66-70 Bokhari, F., 164 Brady, T., 106 Braun, E., 152 Bresnahan, T., 146, 154, 155, 163, 205, 215 British Technology Group (BTG) report, 8, 29,43 Brusoni, A., 110 Chandler, A., 2, 225 Chemical engineering influence in oil and chemical processing industries, 150-152 U.S. systematic university training, 152, 156 Chemical industry licensing of technology in, 187-189 licensing to generate revenues, 172-174use of licensing in, 52-53 Chemical processes diffusion through SEFs, 51-53 market for technology in, 20-22 Chemical processing industry influence of chemical engineering in, 150 licensing of technology in, 52-53 role of specialized engineering firms in, 46-53, 151 suppliers of technology in, 45-46

Chesbrough, H. W., 240 Chin, J. C., 125 Chipless companies. See Semiconductor industry; Specialization Clark, K., 103, 104-105 Coase, R. H., 282 Cockburn, I., 65, 161 Cohen, W., 247 Competition among SEFs, 49-51 influences incentives for licensing, 172-182in markets for technology in chemicals, 20 - 22produced by markets for technology, 182-189, 249 in semiconductor industry, 87 Complementarity of internal and external R&D, 245 in model of know-how transfer, 119-125 in strategies of users and producers of GPT, 154-155 use of know-how with, 116-117 Complex systems, large standards in, 254-255 testing, 109-110 Component Management Group (CMG), 56 - 57Computer numerical control (CNC) machines, 158-160 Contractor, F. J., 118, 124 Contracts. See Know-how contracts Convergence, technological transmission of growth with, 203 Cool, K., 226 Corporate venturing, 240 Cross-licensing agreements antitrust scrutiny of, 269-270 to obtain patented components, 178 patent pools in, 269 royalty payments in, 178 in semiconductor industry, 79-81 Darby, M., 28-29, 43, 66, 199 Dasgupta, P., 256, 273–274 Data sources for analysis of global technology suppliers, 198, 204-205, 216-220 Chemintell database, 48, 198, 204 on cost of know-how transfer, 125

database of Securities Data Company, 32

on licensing contracts, 125-130, 140-141 model of know-how transfer, 125-130, 140 - 141David, P., 254-256, 258, 270, 273-274 DBFs. See Biotechnology industry Decomposition of complex problem, 99–102 Degnan, S. A., 31 Dierickx, I., 226 Digital Greenhouse initiative, 257 Digital signal processors (DSPs), 76 Division of labor in chemical processing industry, 45, 48-49 compared to division of innovative labor, 7, 281-282 in global market for technology, 277-278 horizontal and vertical externalities in, 163 Division of innovative labor based on economies of specialization, 148 in biotechnology sector, 64, 89 compared to division of labor, 7, 281–282 constraints on, 94 costs to transfer information in. 113 factors influencing extension of, 113 gains from, 149-153 in high-tech sectors, 282 organizational design of, 99–102 in semiconductor industry, 76–79 technology transfer as type of, 94 U.S. competitive advantage from, 81-88 in vertical transactions, 6 Downstream sector integration of manufacture in, 83, 86 in vertical market, 6 Economies of scale exploited by GPTs, 145-146 in railroad industry, 149–150 using ASIC technology, 152-153 Economies of scope limited by biotech product-specific research, 161 of specialized suppliers of platform technologies, 161-162 Economies of specialization as basis for division of innovative labor, 148 of engineering design sector, 47

with task-partitioning, 106, 255 in technology production, 247 Eisenberg, 266 Electronic design automation (EDA), 54-55 Ernst & Young, 66, 67 European Union (EU) Commission report on encouragement of risk-taking, 260 CORDIS online service, 83, 258, 286 encouragement to high-tech firms, 286 policy interventions of, 259 Fabless companies. See Firms; Semiconductor industry; Specialization Firms. See also Biotechnology industry; Chemical processing industry; Semiconductor industry; Specialized engineering firms (SEFs); Suppliers, specialized fabless and chip design, 77-78, 81, 256intermediation specialists, 81-83 licensing of technology by large, 175-182licensing strategies of, 231-245 longevity of large, 284-285 markets for technology can affect formation of, 285 resources-based theory of the firm, 224-226 strategic response to markets for technology, 223-251 tacit knowledge of, 95–99 Fosfuri, A., 53 Freeman, C., 48-49 Galambos, L., 64 Gambardella, A., 98-99, 154, 155, 157 Gans, J., 241, 245 General-purpose technologies (GPTs) biotechnology tools, 161–162 cost-minimizing industry structure for, 146 - 149defined, 144 economies of scale using, 149-153 history of, 149 threshold size in use of, 154-155 Granstrand, O., 238 Greenstein, S., 254-255 Grindley, P. C., 2, 9, 238, 269 Grossman, G., 125

Grossman, S., 101 Growth impulse transmission, 197-198, 200-201 Hall, B. H., 79, 81 Ham, R., 79, 81 Hart, O., 101 Heller, M., 266 Henderson, R., 103, 272 Heterogeneity of demand, 249-250 Hodges, D., 76-78 Hofman, D. J., 106 Hsu, D., 241 Iansiti, M., 224–225 Industry structures extensions of model comparing GPT and non-GPT uses, 153-157 and GPT use in some industries, 157-163 machine tool industry, 157-160 model comparing GPT and non-GPT uses, 146-149 standards in U.S. semiconductor industry, 255 and use of GPTs in biotechnology firms, 160 - 163Information diffusion of genetic, 71-74 information system templates, 106 institutions that reduce costs of, 258-261 sharing among biotechnology companies, 70-71 transfer in division of innovative labor, 113 Information, sticky defined, 106 separating out of, 106–107 unsticking, 107-109 Innovation. See also Division of innovative labor EU tax credits for, 260 with fragmentation of knowledge components, 261-267 markets for, 5-6 uncertainty of, 265 Innovation process conditions for integration of, 105-112 decomposability of, 99-102 modularity in, 102-105 open architecture to promote, 255 task-partitioning in, 94, 105-112, 255

Institutions financial, 258-261 intermediating, 258-261 required by markets for technology, 253 - 254standards as, 254-258 Integrated circuits application-specific, 153 microprocessor extends range of, 152-153Integration. See also Application Specific Integrated Circuits (ASICs) dynamic transaction costs of, 110-111 in innovative process, 105–112 of large complex systems, 109-111 in production of technology, 197 Intellectual property. See also Patents chip component designs as, 78 eminent domain policy related to, 269-270 firms' management of, 238-239 increase in strength of rights for, 80 Reusable Application-Specific Intellectual Property Developers, 257 in semiconductor market, 79 Intellectual property rights (IPRs) controversy in GATT over, 125 current prominence of, 117 market-based response to fragmented, 269 in model of know-how transfer, 119 policy of European Union concerning, 286 Intermediation, technological effect of upstream sector, 9, 199, 215 firms specializing in, 81-88 IPSs. See Intellectual property rights (IPRs) Jaffee, A., 272 Joint venture, as horizontal transaction, 6 Khanna, T., 186 Kline, D., 238 Know-how contracts enhancing efficiency of, 116 model of transfer of know-how, 119-137

moral hazard in arm's-length, 115–116 out-based royalties in, 116

Knowledge attributes of, 96

high cost of transfer of, 118 in intangible form, 96 licensing of, 117 organization's internal exchange of, 97 transferability of, 96-99 Knowledge spillovers. See Spillovers, technological Knowledge, tacit (know-how). See also Know-how contracts articulated and codified, 96-99, 105-112 and codified dimensions of, 95 cost to transfer, 115 licensing and transfer of, 117-141 potential for competitive advantage in, 250 sticky information in, 106–109 in task-partitioning, 106–112 Kogut, B., 11, 97-98 Koput, K., 66 Kremer, M., 269 Kuznets, Simon, 1 Lamoreaux, N., 23-27, 56 Landau, R., 156 Langlois, R., 57, 87, 103-104, 110-111, 255, 265 Lemley, M., 62-63 Less-developed countries (LDCs) emergence of chemical industry in, 12-13, 198-216 role of SEFs in, 12-13, 198-216 Levinthal, D. A., 240, 244, 245, 247 Licensing. See also Cross-licensing agreements; Rent dissipation effect; Revenue effect of chemical processes, 20-22 and cross-licensing among semiconductor firms, 77, 80 as horizontal transaction, 6 incentives with market for technology, 2,178-180 by industry sectors, 174-176 international, 175 of know-how or tacit knowledge, 117-125 in market for chemical processes, 20-21 market for technology licenses, 8-9 of metallocene technology, 19-21 of polyethylene technology, 21-22

embodied in software program, 3-4

forms of technological, 3-4

reasons for, 175, 177–178

for revenues, 19, 172-175, 228 royalty income from technology, 80-82 SEF practices, 52 in semiconductor industry, 79-81 Licensing strategies competition influences incentives for, 172–182 of firms to profit from their technology, 234-238 of large firms, 231-240 in model of technology market competition, 182–189 of smaller firms, 242-245 Lieberman, M., 51-52 Linden, G., 55, 77 MacDonald, S., 152 Macher, J., 76-78 Mahoney, J. T., 104, 111-112 March, J. G., 240, 244, 245 Markets for assets competing firms in, 225-228 transaction costs in, 229 Markets for innovation, 5–6 Markets for technology. See also Technology transactions appropriability problem, 93 in chemical processes, 20-22, 46 comparison of industrialized countries', 31-42 defined, 5 dynamic issues of, 283-284 effect on business formation, 285 function of, 8-10 growth (1990s), 43 horizontal and vertical transactions in, 6-8,281-282 incentives to license with, 178-180 institutions required by, 253-254 in less-developed countries, 198-216 metallocene technology, 17-20 model of competition in, 184-189 most developed sectors in, 33-41 nineteenth and early twentieth centuries, 23-27 promote incentives to invest in R&D, 8 in semiconductors, 76-88 size and scope of, 29-42 specialization advantages in, 144 technological standards in, 256–258 typology of, 7-8

worldwide, 43, 275-278 Marshall, Alfred, 28 Merges, P., 186, 234, 261, 263 Metallocenes as catalysts for polymers, 17-18 licensors of technology for, 19 market for technology of, 17-20 Microprocessors, programmable, 152 Modularity in chip design, 78 in problem solving, 105 in product design, 103–104 in production, 103 systemic uncertainty with, 109-111 Moore, J., 101 Morel, B., 164 Mowery, D., 2, 76-78, 113, 245, 270-272, 274-275 Nelson, R. R., 1, 11, 95, 263 Nonaka, I., 97 Numerical controls (NCs) technology, 159-160. See also Computer numerical control (CNC) machines O'Brien, D., 62-63 Oil industry specialized engineering firms in, 151-152 use of licensing in, 52–53 Orsenigo, L., 66-67 Outsourcing, 148 Pakes, A., 30 Patents as bargaining chips in cross-licensing, 80 blocking, 264–265 define some property rights, 93 as facilitators of technology transactions, 261-267, 271 issues to U.S. universities, 270-275 in model of know-how transfer, 119-125 in model of technology market competition, 182-189 rights in model of transfer of know-how, 119-137 semiconductor, 79-81 software, 60-63 value of, 30 Patent system influence on markets for technology, 24

Patent system (cont.) new patents in 1840-1911 period in United States, 23–27 proposed changes in patent-pooling agreements, 268-270 recommended improvement of, 267-268,286 Pharmaceutical industry biotech suppliers to, 161-162 interdependence in innovation process of. 162 Pisano, G., 224 Polanyi, M., 95 Polymers production using metallocenes, 18 production using Ziegler-Natta catalysts, 17–18 Polyolefin industry, 18 Polypropylene, 19 Powell, W., 66 Prencipe, A., 110 Privatization of knowledge, 274-275, 279 of university-based research, 270 Property rights. See also Intellectual property rights (IPRs) on tangible and intangible goods, 93 transaction costs affected by, 229 when ownership is fragmented, 261-267 Public policy funding for U.S. university-based research, 270-275 interventions of, 259 recommended improvement of patent system, 267-268 to reduce transaction costs, 254-261 related to privatization of knowledge, 270-275 related to standards and standardsetting, 258 role in global marketplace, 275-279 role of standards in, 254-258 Railroad industry increasing returns to scale in, 149-150 modern management techniques of, 150 Reiss, P., 205 Rent dissipation effect defined, 179

in firm's decision to license, 231

in model of technology market competition, 182-189 Research and development (R&D) European public policy related to, 259-260firms' need to invest in, 245 incentives for investing in, 192–194 knowledge spillovers in, 27-29 outsourcing of, 148 technology buyers need to invest in, 245 U.S. tax credit policy, 260 Reusable Application-Specific Intellectual Property Developers (RAPID), 257 Revenue effect defined, 179 in firm's decision to license, 231 in model of technology market competition, 184-189 Rivera-Batiz, L., 200 Rivette, K. G., 238 Robertson, P. L., 57, 87, 103-4, 255 Rockart, J. F., 106 Romer, P., 200, 215 Rosenberg, Nathan, 9–10, 146, 202–203, 245Rostoke, Michael, 266 Rotemberg, J., 246 Saloner, G., 246 Sanchez, R., 104, 111–112 Schankerman, M., 30 Schumpeter, J., 225 Scott-Kemmis, D., 128, 136 Securities Data Company, 32–33, 40 SEFs. See Specialized engineering firms (SEFs) Semiconductor industry chip design firms, 77-78 fabless and chipless companies in, 77, 81.256 licensing and cross-licensing in, 77 licensing to generate revenues, 174 manufacturing technology of, 76 markets for technology in, 81 miniaturization process, 76 software tools used by, 54-55 Semiconductors demand for design-intensive, 78 production increases, 76 trade in design modules, 77 U.S. patents for, 79-81 Semiconductor technology

CMOS technology, 256 gene chip development, 74 laboratory on a chip products, 74-75 Simon, Herbert, 99, 102, 105 Smith, Adam, 6 Smith-Doerr, L., 6 Software compatible component market, 56-57 cost to produce and reproduce, 53-54 developed by dedicated biotechnology firms, 70-76 electronic design automation, 54-55 industry structure and use of GPTs in, 157 - 160as knowledge tool, 54-56 licensed, 53 market for modules and components of, 56 - 60patenting of, 60-63 role in markets for technology, 53-63 technology transactions in, 56-60 Sokoloff, K., 23-27, 56 Somaya, D., 55, 77 Specialization. See also Economies of specialization; Specialized engineering firms (SEFs); Suppliers, specialized advantages to, 143-144 in chipless companies, 77 in division of innovative labor, 7 in electronics industry, 146 in fabless design firms, 77, 81, 256 firm choices related to, 164 Specialized engineering firms (SEFs). See also Chemical engineering in chemical processing industry, 12–13 comparative advantage in industrialized countries of, 199-200 comparative advantage in process design of, 47-51 comparative advantages of, 47-51 conditions for emergence of, 46–51 as independent licensors, 47 as licensing agents, 52 process technology of, 47-48, 52 as suppliers of chemical process technologies, 247-248 as suppliers to less-developed countries, 200-216 Spillovers, technological effect of, 9 as externalities, 27-28 international, 199-215

as knowledge transfers, 9-20 upstream sector intermediation effect, 9, 199, 215 Spitz, P. H., 51, 52, 151-152 Standards, technological CMOS interfaces, 256 CORBA component-management technology, 256-257 standard-setting alliances, 257–258 State Street Bank & Trust Co. v. Signature Financial Group Inc. (1998), 61 Steinmueller, W. E., 255 Stern, S., 241, 245 Stigler, G. J., 6, 112-113, 143, 145-146, 149 Stiglitz, J., 244 Sturchio, J., 64 Suppliers, specialized barriers experienced by, 259 to chemical processing industry, 150-151 dedicated biotechnology firms as, 64 as developers of GPT, 144 of general-purpose technologies, 144 to less-developed countries, 200-216 operating in vertical markets, 9 of platform technologies, 161–162 in semiconductor industry, 86 of technology in chemical processing industry, 45-46 technology transfers by, 200 Supreme Court decisions about patenting of software, 61 Task-partitioning, 105–112, 255 Technology. See also General-purpose technologies (GPTs) accounting for value of assets of, 29-30, 260-261 appropriating rents from, 228 choice between outsourcing or division of innovative labor, 148 distinct from technological capability, 284efficient contracts for exchange of, 116 embodied in physical artifacts, 3-4 firms' in-house exploitation of, 229-232 forms of exchange of, 2 inter-industry flows of, 31-43 licensing to generate revenues, 172-174

production of, 6–7

R&D outsourcing in, 148

Technology (cont.) role of SEFs in diffusion of, 51-53 royalties on, 31-32, 40 as tradable object, 284 Technology transactions. See also Transaction costs appropriability problems limited by, 93 cognitive factors limit, 94 for creation of new technology, 5-6 inter-industry, 31-42 markets in. 4 need for data related to, 285 patents as facilitators of, 261-262 services facilitating, 24, 81–88 in software, 56-60 for use and diffusion of technology, 5 Technology transfers adaptations and cost of, 94 appropriability problems of, 93-94 cost of, 95 in model of technology market competition, 182-189 multinational enterprises as vehicles for, 200 software, 60 Teece, D. J., 2, 9, 11, 98, 101-102, 224, 227, 228, 238, 269, 282 Tiernay, M., 106 Trajtenberg, M., 146, 163, 215, 272 Transaction costs factors influencing, 229-230 in markets for assets, 229 in model of technology market competition, 182–189 recommended policy to reduce, 254-261 Uncertainty in innovation, 265 systemic, 109-111 U.S. Patent Office business process patents granted by, 61 software patents granted by, 61-63 Universities, U.S. apply for patents and copyrights for research, 270-271 licensing of patents by, 271-272 in market for technology, 270 privatization of university-based research, 270 Upstream sector in biotechnology industry, 67-70

intermediation effect of, 9, 199, 215

in vertical technology transactions, 6 Venture capital compared to corporate venturing, 240 flexibility of firms offering, 259 R&D tax credit as asset for, 260 U.S. firms in other countries, 27 Vernon, R., 200 Vincenti, W. G., 100, 102 Virtual Component Exchange (VCX), 257 Virtual Socket Interface Alliance (VSIA), 257 Virtual Socket Interface (VSI) technology, 79 von Hippel, Eric, 11, 105-107, 112, 245 Weiss, A., 244 Williams, R., 106 Williamson, O., 282 Winter, S., 11, 95-96 Young, A., 6 Zander, U., 11, 97–98 Ziedonis, A., 271-272 Zucker, L., 28-29, 43, 66, 199