

## Dissemination of Knowledge

*If knowledge from the projects is disseminated—either through products and processes commercialized by the innovators, or through publications, patents, and other modes of knowledge transfer—it may benefit other producers in the economy and, subsequently, consumers. The resulting national benefits may go far beyond the returns to the innovating firms and the benefits to their customers.*

### Multiple Ways of Disseminating Knowledge

New knowledge developed in a project can be diffused in a variety of ways. One way is through the observation and reverse engineering of the new goods or services produced directly by the innovators and their partners. Other ways, discussed here, are patents filed and granted by the U.S. Patent and Trademark Office (USPTO) and cited by others; interactions among research partners, suppliers, customers and others and movement of project staff to other organizations; preparation of technical papers that are published or presented at conferences; distribution of nonproprietary project descriptions by government funding agencies; and project-related workshops and meetings.

These pathways allow others to obtain the fruits of R&D without having to pay the full cost of it. When the technology is particularly enabling—in the sense of providing radically new ways of doing things, improving the technical bases for entire industry sectors, or being useful in many, diverse areas of application—the spillover benefits to others are likely to be particularly large.<sup>11</sup>

### Balancing Intellectual Property Protection and Knowledge Dissemination

The ATP encourages broad dissemination of knowledge produced in ATP-funded projects because it increases the number of potential users of the knowledge, and, therefore, may increase national benefits. But, at the same

time, ATP does not force innovating companies to compromise their ability and willingness to pursue early commercial applications of the technology by giving away all of their intellectual property. After all, these companies, which contribute a substantial share of the costs, have agreed to tackle difficult research barriers and to take the technology to the marketplace as rapidly as possible.

Thus, it is not surprising that the amount of knowledge dissemination varies among ATP projects. Most of the projects display some forms of deliberate knowledge dissemination, such as publishing scientific papers and giving presentations. Most projects also display considerable unintended knowledge dissemination: for example, as others acquire the innovating company, as its scientists move and work among other companies and universities, and as a myriad of formal and informal discussions occur.

### Public Disclosure of Patent Filing Information

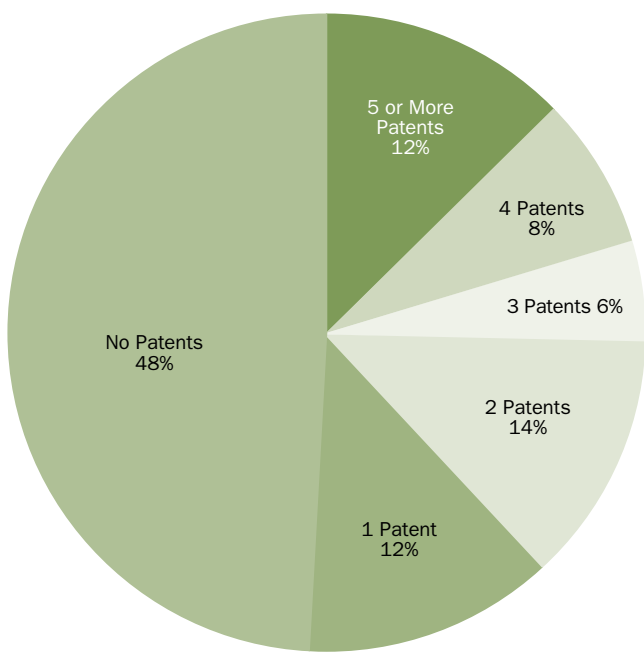
When applying for a patent to protect intellectual property, an inventor must explicitly describe the invention. Because patent law requires that the invention be both novel and useful, the inventor must demonstrate that the invention is essentially different from any other invention and must describe how it can be used. When the USPTO grants a patent, the full application text describing how the invention may be used and how it is related to other technologies is put into the public record and becomes a

<sup>11</sup> The generation of spillover benefits, or positive externalities, from technological advancement is an important argument for public support of enabling technologies.

medium through which knowledge is transferred to others.<sup>12</sup> Hence, patents serve to disseminate knowledge.

At the same time, patent data are not perfect signals of knowledge creation and dissemination.<sup>13</sup> The decision to seek patent protection for intellectual property is influenced by many factors, including the ease with which others can copy the property's intellectual content and the difficulty of defending the patent position from infringers. Some companies may decide that patent protection is not worth its expense, or that a strategy of trade secrets and speed to market is a more effective strategy. Or, patents may be filed as the basic ideas are forming, and trade secrets used in later stages. Furthermore, the importance of patents as a strategy varies among technology areas, and figures more strongly in electronics and manufacturing, for example, than in computer software. As a consequence,

**Figure 1.2 Distribution of Projects by Number of Patents Filed**



the absence of a patent does not mean that intellectual property was not created. But the presence of a patent is a signal that it was created.

Of the 50 projects, 26 projects had filed 115 patents at the time the study data were collected.<sup>14</sup> Twenty-one of the projects had among them a total of 64 patents granted. Fifteen of the projects had filed a total of 51 patents that had not yet been granted.

Figure 1.2 displays the distribution of the 50 projects by the number of patents filed—including those granted and not yet granted. Participants in 12 percent of projects had filed a single patent, and in another 12 percent, 5 or more patents. Participants in 18 percent had filed from 1 to 5 patents. Nearly half of the projects had yet to file patents or have them granted.

### Knowledge Disseminated by Patents as Revealed by Patent Trees

Each published patent contains a list of previous patents and scholarly papers which establish the prior art as it relates to the invention. The citations provide a way to track the spread of technical knowledge through patents granted to ATP-funded projects. By following the trail of the patent referenced, it is possible to construct what looks much like an inverted genealogy tree.

Once the pool of ATP-related patents was identified, computerized tools made available by the USPTO were used to track subsequent patents that refer to each of the ATP-related patents as prior art and the links recorded.<sup>15</sup> The process is then repeated in turn for each of these patents, until the chain of references is complete. Next, the information is converted into graphical form, with the diffusion of knowledge along the path from ATP project patents represented by links from node to node in the tree.

With the passage of additional time, new branches may spring up from nodes at the outer edges of the tree, from nodes deep inside the tree, or from their base. To the extent that later patents are dependent on the earlier

<sup>12</sup>The U.S. copyright system, also administered by the USPTO, works somewhat like the patent system. Although a writer or other creator of a work or expression has an inherent copyright, the creator may register the copyright with the USPTO for added protection. For technology creations, protection via copyright generally is not as useful as patent protection. When patenting is an option, it is usually chosen over copyright registration. Patenting was the option favored by this group of ATP-award recipients, and is the focus here.

<sup>13</sup>Despite the limitations, patent statistics serve as useful indicators of knowledge creation and dissemination, and they are widely used by researchers.

<sup>14</sup>Patents filed and not yet granted are included here, in addition to those filed and granted, despite the fact that there is no public disclosure until patents are actually granted. The reason for including patent filed, not yet granted, is to help offset the problem that there are substantial differences across industries in the lag time between patent filing and grant. Due to the lag time, the absence of patents granted at the time data were collected for the report does not mean that patents filed will not be granted in the future. Any over-count that may result from the inclusion of patents filed that ultimately failed to be granted is likely compensated by inadvertent omissions of patents granted from the data collection.

<sup>15</sup>The references to prior patents contained in a published patent are based on information supplied by the applicant and on research by USPTO researchers. There is no way to distinguish between the two sources and no indication that one tends to dominate the other. (USPTO telephone interview with ATP staff, February 11, 2000).

ones, the patents in the tree represent developments in knowledge that would not have occurred, or at least not in the same time frame, had the ATP not stimulated the creation and dissemination of that platform knowledge.

### **Patent Tree Illustrating International Knowledge Dissemination**

Figure 1.3 is a patent tree for one of the 50 completed projects, a project to develop wafer ion-implantation, carried out by Diamond Semiconductor Group (DSG), a two-person start-up company in Gloucester, Massachusetts.

The company received two patents for work in its ATP projects, and had filed two additional patents from project-related work at the time the data were collected for this study. One of the patents granted in 1996, number 5,486,080, entitled “High speed movement of work pieces in vacuum processing,” involved the robotic transfer of wafers in the fabrication of microprocessors. In the following year, two patents—one granted to VLSI Technology and the other to Hitachi—cited the DSG patent. In 1998, three additional patents—granted to Eaton, Fanuc, and Tokyo Ohka Kogyo—directly cited the DSG patent. An additional patent—granted to Jenoptik, cited the Hitachi patent—thus indirectly citing the DSG patent. In 1999, two additional patents—granted to Applied Materials and Dainippon—directly cited the DSG patent, and five new patents indirectly cited the DGS patent. Four of these citations are once removed: a patent granted to Cypress, a second patent granted to Applied Materials, and two patents granted to GaSonics International; and one is twice removed: a patent granted to SEZ.

As explained in the project write-up for DSG (See Diamond Semiconductor Group, LLC, Chapter 4), the ATP award was instrumental in enabling the company to form an early licensing agreement with Varian Associates, a U.S. ion-implant equipment manufacturer located in Massachusetts, that rapidly incorporated the new technology into its equipment. This relationship provided a strong direct path to swift impact through a U.S. company. As illustrated in Figure 1.3, the indirect path for this project was also active and the knowledge has been spreading quickly to companies around the world.

### **Patent Trees Illustrating Project Impact through Knowledge Dissemination**

The patent tree in Figure 1.4 shows citations of one of three patents that came out of Armstrong’s project to develop new materials for next generation thermal insulation. Company reorganizations, strategy shifts, and cost estimates toward the end of the project led Armstrong to

drop its plans to produce the materials.

The patent tree illustrates how an ATP project whose direct path appears to have slowed or come to a standstill nevertheless has the potential for impact through knowledge spread by patent citations along the indirect path of project impact. As the patent tree illustrates, other companies, including Dow Corning, are referencing the Armstrong patents, and the potential for beneficial impact from the research continues. (See Armstrong World Industries, Inc., Chapter 6.)

Figure 1.5 shows citations by other companies of 3 patents resulting from a project led by ETOM. ETOM had filed 12 patents that had been granted, and 14 more not yet granted by the end of its ATP project. The small company then went bankrupt. The patent tree illustrates how knowledge can survive a failed creator, and continue to be disseminated. An observer who equates business success of the innovator, one-to-one, with ATP-project success may be mistaken, because the indirect path may nevertheless produce important benefits. (See ETOM Technologies, Inc., Chapter 6.)

### **Patent Tree Illustrating Extensive Knowledge Flows**

Figure 1.6 illustrates just how complex knowledge flows through patent citations can become. The path shown is for patents resulting from an ATP-funded joint venture led by Kopin. The project developed methods to interconnect thin-film integrated circuits side-by-side or in layers. Obviously, the work has generated substantial interest. This project also has an active direct commercialization path. (See Multi-Film Venture, Chapter 4.)

Chapters 2 through 6 provide patent trees, current as of February 2000, for many of the projects that have received patents. Although representing only one aspect of knowledge dissemination, the patent trees extend awareness of the influence of the new knowledge.

### **Knowledge Dissemination through Other Means**

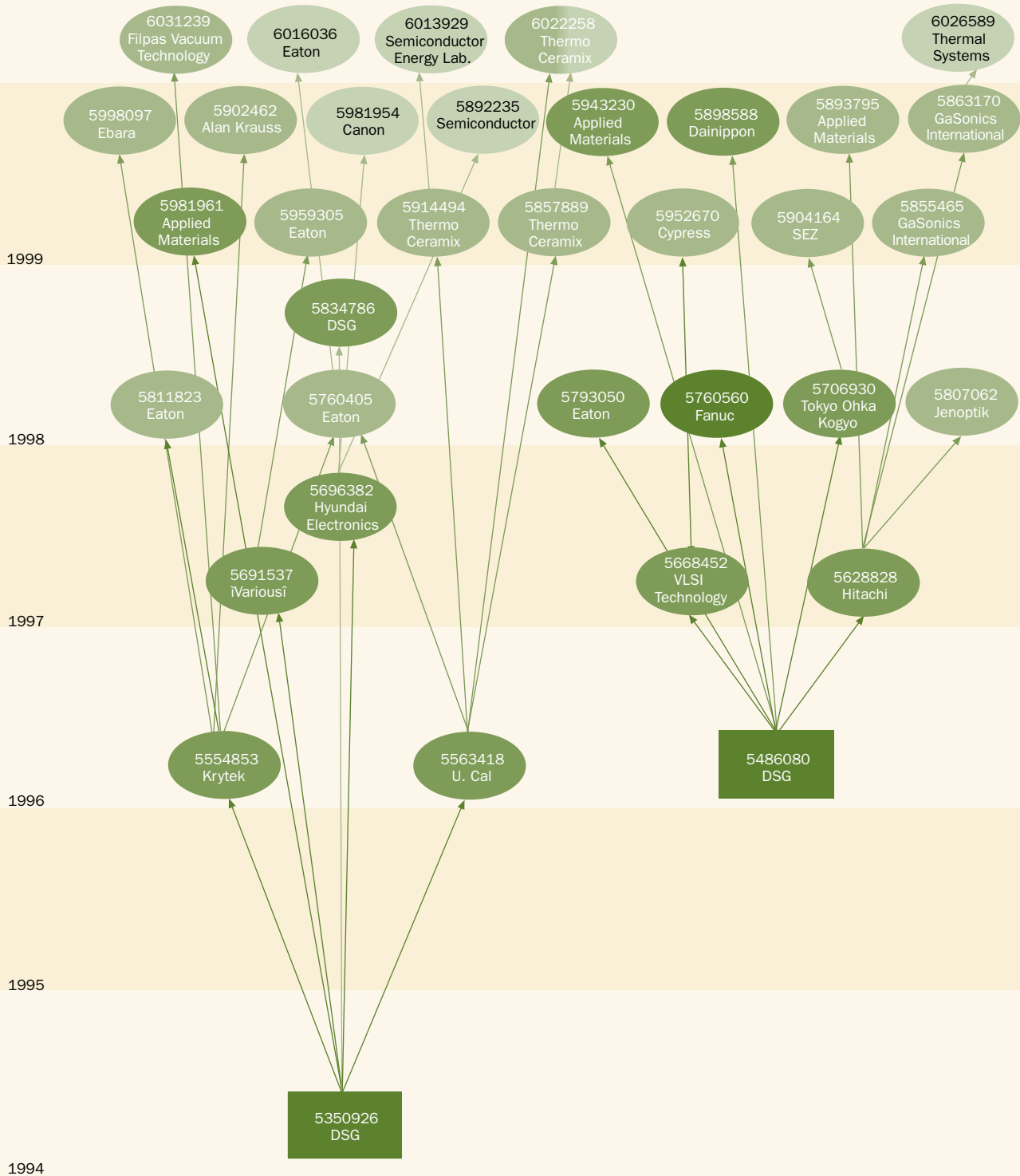
Participants in more than half the 50 projects published and presented papers in technical and professional journals and in public forum. Altogether, the companies published at least 180 papers and presented 245 or more papers.

Figure 1.7 gives the distribution of projects by their numbers of publications and presentations. Thirty percent of the projects each yielded 1 to 5 papers published or presented. At the high end, six percent of projects each had more than 20 papers published or presented.

PATENT TREE KEY

- Original Patent
- Second Generation Patent
- Third Generation Patent
- Fourth Generation Patent
- Fifth Generation Patent

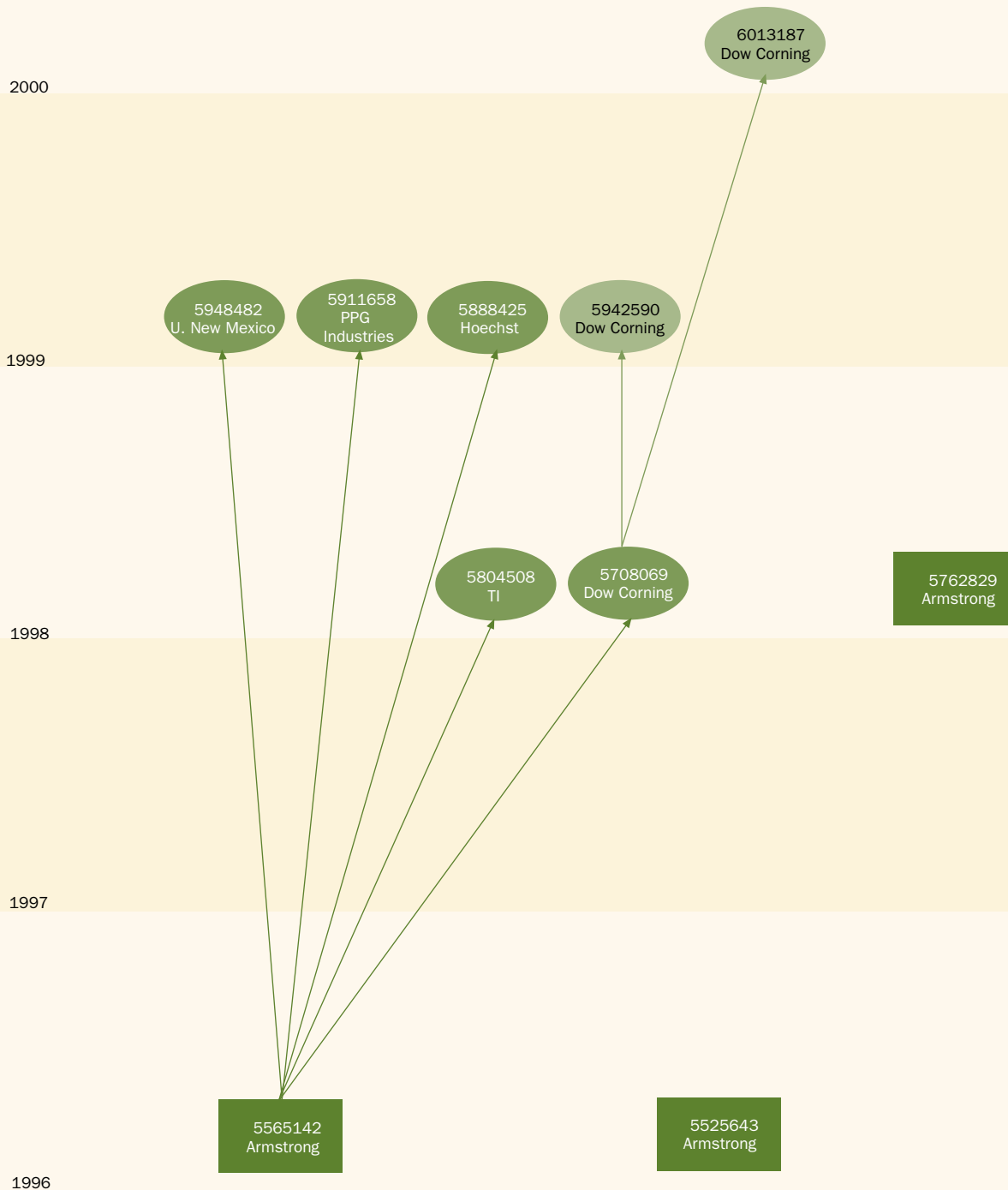
**Figure 1.3 Project Impact Through Patent Citations, Paralled by Strong Activity by Innovator**



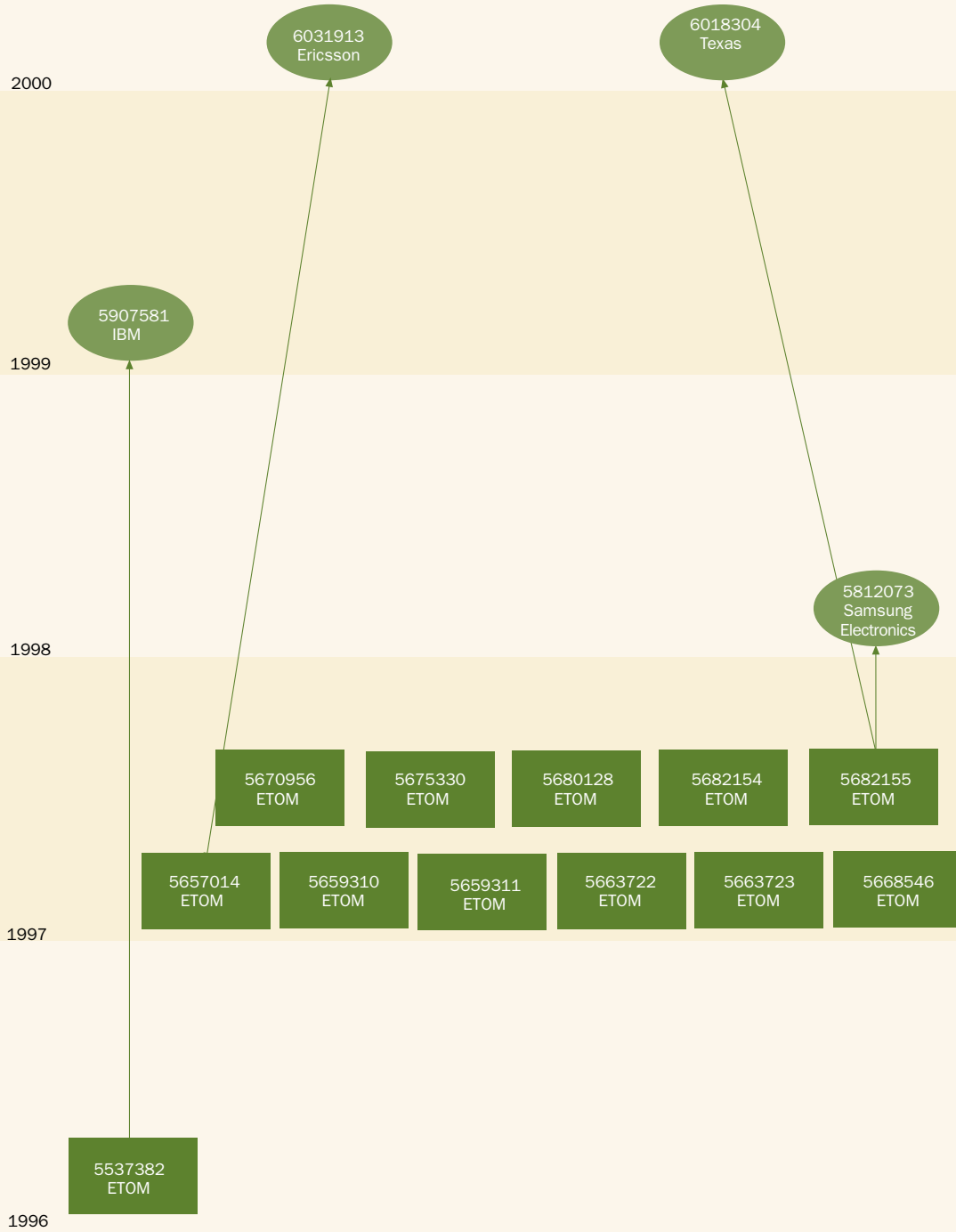
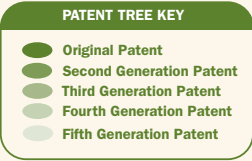
PATENT TREE KEY

- Original Patent
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- Third Generation Patent
- Fourth Generation Patent
- Fifth Generation Patent

Figure 1.4 Project Impact through Patent Citations, after Innovator Reduced Activity



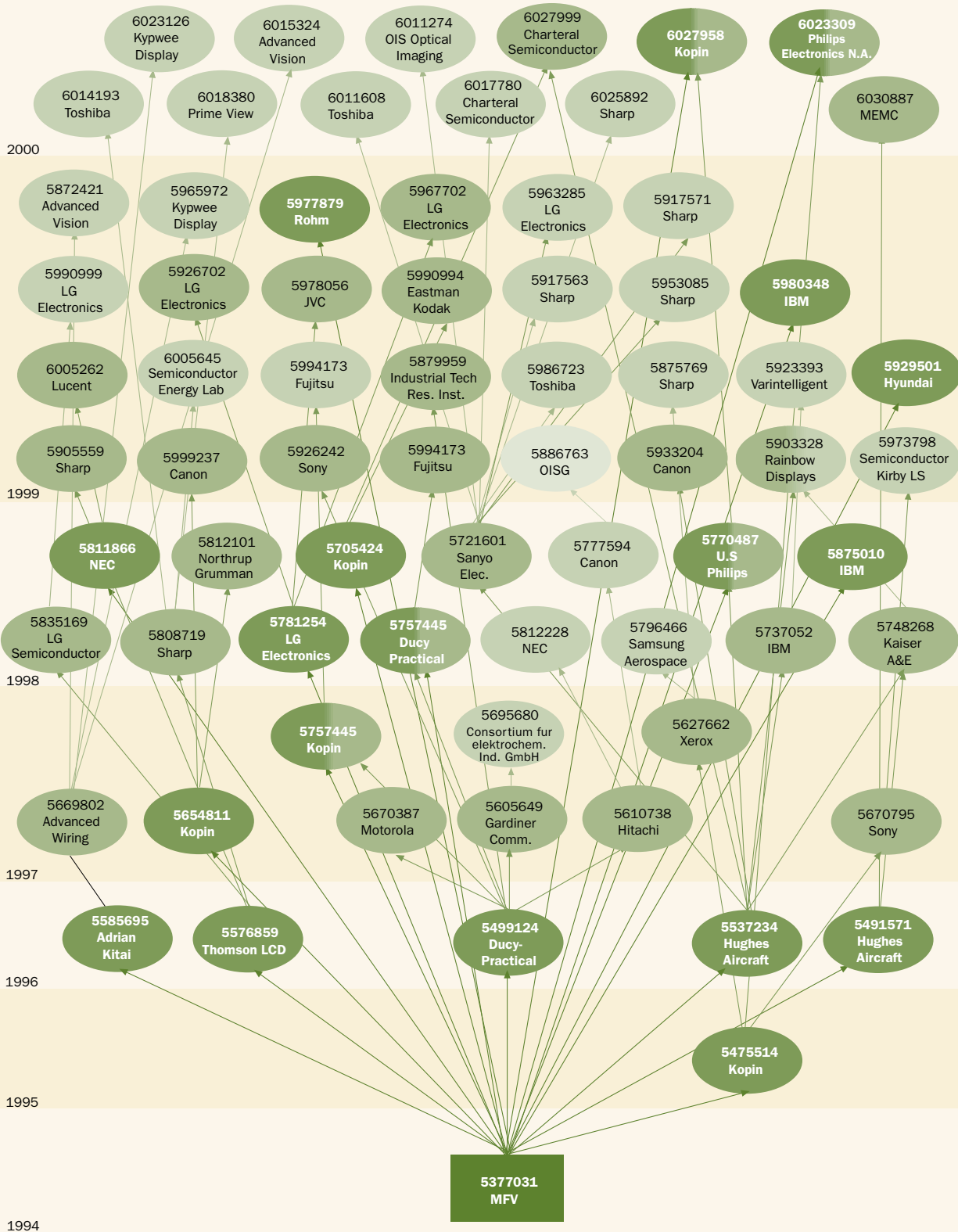
**Figure 1.5 Project Impact Through Patent Citations, after Innovator Went Bankrupt**



PATENT TREE KEY

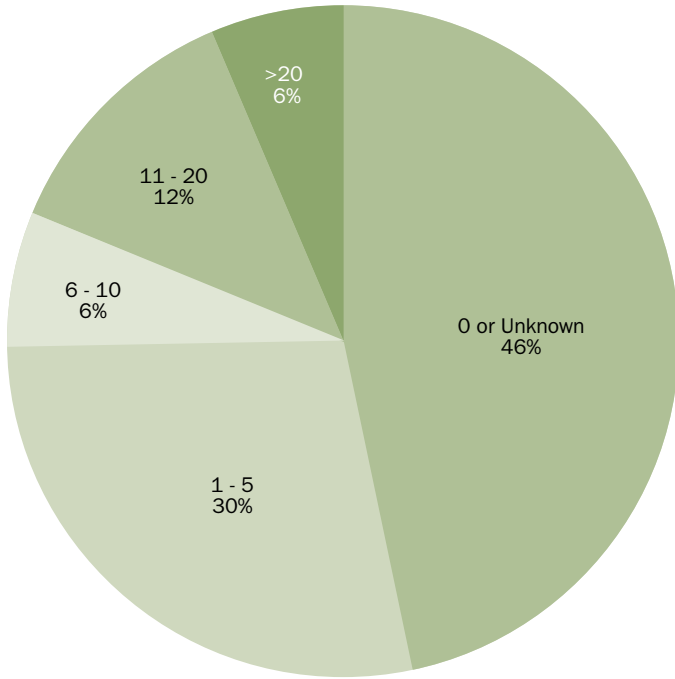
- Original Patent
- Second Generation Patent
- Third Generation Patent
- Fourth Generation Patent
- Fifth Generation Patent

**Figure 1.6 Patent Tree Illustrating Extensive Knowledge Flows**





**Figure 1.7 Distribution of Projects by Number of Publications and Presentations**



Aside from publishing, presenting, and patenting, ATP projects have a high rate of collaborative activities. (See Table 1). With so many partners, collaborators, and subcontractors involved, it would be difficult to lock up the information. These many participants in the projects provide rich avenues of further interaction with others, and these interactions in turn may increase knowledge flows through personal and professional contact.

When the government enters into an agreement with an organization, certain information about the agreement is generally made public. Such is the case with the ATP and company cost-sharing partnerships. Nonproprietary information has been disclosed to the public for each of the

522 projects funded by the ATP through 2000. Project information is available on the ATP website on the Internet (<www.atp.nist>), and new nonproprietary project descriptions are added to the site as new awards are made. Evaluation reports, such as this one, also provide information to the public.

To help the public learn more about the projects it funds, ATP organizes and sponsors numerous public workshops, where companies present nonconfidential aspects of their ATP-funded research and engage in open discussions. These workshops facilitate information flow among ATP award recipients, and from them to other companies, ATP project managers, other government program managers, the press, potential investors, and universities.

When a good or service incorporating new technology reaches the marketplace, a buyer can learn a great deal about the technology. The mere functioning of a new product reveals some information. Intentional investigation, including reverse engineering, reveals even more. More than 60 percent of the 50 projects reviewed for this study had some commercial products or processes based on the ATP-funded technology already on the market, which means that product use and examination are providing others with information about the new technologies.