Conclusions

The large intellectual property policy changes of the last quarter century—the extension of patenting and licensing by inventors in universities and government laboratories, the creation of the Court of Appeals for the Federal Circuit, the extension of patenting to new technological areas, and the attempts to harmonize IP protection internationally—have resulted in complex changes in behavior by private firms, universities, and Federal laboratories. The number of utility patents granted by the U.S. PTO has grown rapidly, and all three kinds of institutions have increased their patenting.

(1) *In general, ARS patents and licenses innovations as a means of technology transfer and not as a means of generating revenue.*

The most notable indirect evidence that revenue generation is not a major motivation for ARS patenting is how licensing funds are used. ARS licensing revenue is used to fund the operations of its OTT, not as a major source of research funding. In 2000, licensing revenue was only about 0.3 percent of ARS's R&D budget.[39]

[39]The use of licensing funds to support OTT is similar to the practices of other Federal labs.

The differences between university patenting trends and those of ARS is further indirect evidence that patenting and licensing by ARS is primarily done as a means of technology transfer. Although private firms still receive the vast majority (around 95 percent) of utility patents, patenting by U.S. universities has increased very rapidly, partly in response to specific policy factors such as the passage of the Bayh-Dole Act of 1980. But university patenting began to increase rapidly before the passage of the Act, so it cannot have been the only factor.[40]

[40]For discussions of the relative roles of the Bayh-Dole Act and other factors in stimulating university patenting, see Henderson, Jaffe, and Tratjenberg (1998); Jaffe (2000); and Mowery et al. (2001).

Invention disclosures, patent applications, patent grants, patent licensing, and the use of related technology transfer mechanisms such as CRADAS by Federal Government research agencies have also increased in recent years, but available data suggest that these trends began later and were more modest than equivalent trends for universities. This pattern of more rapid growth in patenting and licensing by universities is also seen more specifically when comparing land grant universities with ARS. It is also paralleled in trends for particular technologies, for example, agricultural biotechnology.

Other indirect evidence that ARS patents and licenses primarily to transfer technology can be found. The ARS patent-application process follows careful protocols, with specific questions asked at each step. An important question is the likelihood of finding an acceptable private sector partner for commercialization of the technology. These questions are in addition to discovering the likelihood that a patent can be granted.

(2) *The ARS Office of Technology Transfer (OTT) operates in a different environment than university OTTs.*

Protocols for technology transfer through licensing are more restrictive for the Federal Government than for universities. As one example, ARS must publish intent to offer an exclusive license in the *Federal Register*. This may create greater incentives for eventual licensing by more than one firm. More generally, the Federal Government follows specific guidelines in the Code of Federal Regulations to ensure transparency and fairness in its licensing arrangements.[41] All other things equal, first preference for federally licensed technologies is given to smaller firms (typically fewer than 500 employees).

[41]For example, although license terms are confidential, the identity of licensees is not.

(3) *Increased patenting and licensing by ARS has not been associated with a decline of traditional instruments of technology transfer such as scientific publications.*

From 1990 through 2003, as ARS patenting and licensing (and other newer means of technology transfer, CRADAs) have increased, scientific publication counts for ARS have remained relatively stable. In general, this conclusion holds when output counts are normalized either by scientist-years or by ARS budgets.

(4) Ex ante *determination of successful licensing terms and practices is very difficult. The success of a license depends on market size, market characteristics, and technology characteristics, and is subject to both "technology risk" and "appropriation risk." Potential market and technology parameters are often not known in detail when licenses are negotiated, and reasonable people might disagree about them.*

Many patents are issued at a proof-of-concept stage, or some other preliminary stage of development. Technology risk refers to the probability that a technology can be improved and developed into a feasible commercial product or process that is an improvement over available alternatives. Appropriation risk is related to the likelihood that a company will be able to earn profits from the new technology and not have them captured almost entirely by competitors. Both the OTT and the technology partner must agree first, to license, and second, to specific license terms in the absence of complete information. Patenting and licensing are one means of addressing appropriation risk, but changing the exclusivity in licensing terms can change appropriation risk. Furthermore, market characteristics influence the effects of exclusivity on appropriation risk. These characteristics include the nature of the demand for products embodying the technology, the size of the market, the degree of competitiveness in the market, and the expected growth of the market.

Performance incentives such as milestone requirements or periodic licensing fees are aimed at reducing technology risk on the part of the licensee. Using patents as a factor in evaluation of ARS scientists and rewarding successful patenting monetarily are incentives for reducing technology risk from the side of ARS.

(5) *ARS does retain some flexibility in renegotiating license terms.*

Flexibility in license terms is necessary when unforeseen circumstances arise. In particular, the relevant market size and characteristics may become clearer over time. Similarly, different characteristics of a particular technology may turn out to have greater market potential than initially envisioned. *Ex post* flexibility can correct *ex ante* mistakes in predicting technology success or failure.

(6) *Licensing to more than one firm is more likely to be successful if the market is segmented geographically or by stages in a production process than if all firms are competing for the same market niche.*

This phenomenon was observable within the case studies. In particular, co-exclusive licensing in which licensees are direct competitors for the same market niche can reduce collaborative efforts with ARS inventors in product development. The potential for direct market competition in an uncertain environment can also reduce the incentives for product development. Exclusive licensing by territory or field of use, on the other hand, can lead to greater success in transferring technology. When licensing is used to segregate markets geographically or by stages of production, synergies can be created in the market, enhancing the use or spread of the technology.

Using the single policy instrument of patenting and licensing to attempt to achieve multiple Federal policy goals is not feasible. Both the "mission technology" paradigm—the government conducts research in support of missions in which there is a national interest—and the "market failure" paradigm—the government conducts research when private markets do not provide the socially optimal amount and kind of research—help to explain why USDA conducts research in the first place. Under both paradigms, it is plausible to assume that a great deal of USDA's research has been socially valuable even when it has not resulted in a relatively near-market, patentable technology. Estimates of positive returns to public sector agricultural research (Federal and State) confirm this view.

Because much ARS research cannot be directly commercialized, it is unlikely that generation of substantial revenue from patents and licensing would be a major goal of that instrument. The evidence suggests that it has not been. Other potential uses of government patenting that we initially considered were promoting awareness of public research results, bringing credit to the Federal agency performing the work, or patenting defensively to maintain freedom to operate or to encourage widespread use of federally developed research tools. Awareness and credit may be two results of ARS patenting, but they are clearly side benefits, not major motivations for patenting. In any case, other ARS technology transfer instruments also provide these benefits. The third motivation mentioned here, defensive patenting, may be justifiable but there is little evidence that it plays a role in patenting by ARS. There is a public interest in maintaining access to ARS technologies, but discussions of patentability by Patent Review Committees focus much more on finding a commercial partner than on preventing a private firm from gaining access to ARS technology and blocking others from using it. It would arguably be more likely for ARS to choose scientific publication over patenting as a major strategy in the case of a research tool that is expected to be widely applicable.

By focusing on technology transfer in situations where patenting and licensing are necessary to ensure private firm interest, ARS has reduced some of the inherent contradictions in a multiple-goal environment. Some of the tools used by ARS—issuance of licenses that are exclusive by territory or field of use, *ex post* flexibility in adjusting licensing terms—clearly help to maintain a balance between meeting Federal policy goals and making sure technology that can be commercialized actually is commercialized.

ARS's use of a broad range of technology transfer mechanisms, not restricted solely to patents and licensing, also helps to preserve this balance. Additional steps might make the patent and licensing process smoother in situations in which these instruments are chosen—for example, reducing the requirements that lead to multiple licenses when markets are overlapping, or further increasing the flexibility in negotiating licensing terms.

In short, patenting and licensing can be consistent with the objective of widespread distribution of the benefits of ARS research. A technology that reaches society through private sector development of ARS research may provide more net social benefits than a technology that is not developed at all because no private firm commercializes it—provided technology transfer activities do not withdraw too many resources from ARS' most important missions. This conclusion is likely applicable to other Federal research agencies, especially when legal requirements for technology transfer are the same for these agencies. On the other hand, Federal research agencies differ in the size of research budget, in the markets for possible commercial applications of their research, and in management structure (particularly for research conducted by outside contractors). As a result, there may also be subtle differences in specific technology transfer practices at other agencies. Further research would be needed to understand how our findings might apply to practices in other agencies.