Public Value Mapping applied to technology transfer policy.

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1. Introduction

During the last three decades the policy response to a perceived crisis of competitiveness in the US has resulted in government efforts to increase the productivity of the national industry, a goal that in itself improves domestic and international competitiveness, but also because productivity gains support stable long-term economic growth (Mowery and Rosenberg, 1989). An important part of these efforts has been to build the institutional capacity to maximize the return of public investment in technological innovation; these efforts encompass the system of laws governing intellectual property rights. IPRs are particularly germane to the process of transfer of innovations from universities and government laboratories to private industry. In fact, the cornerstone of technology transfer policy in the US, the Bayh-Dole Act of 1980[1], ceded all intellectual property rights on the patented knowledge produced by federally funded research institutions.

This paper is concerned with policy evaluation theory and its application to technology transfer policy in the US. The assessment of technology transfer policy confronts two major difficulties when traditional approaches to evaluation are considered. The first is that, as suggested above, Bayh-Dole is only one piece of a larger package of policies aimed at boosting national competitiveness. Thus, it is cumbersome to characterize properly a comparison group because the size and complexity of the US innovation system is somewhat singular to other countries generally used for comparison (e.g. OECDs). The decentralized character of the US policy process and the absence of central planning of science policy in the US only compounds the problem of finding a comparison group. The alternative to finding a comparison group is generally that of producing a counterfactual from the time series of the dependent variable. This is also difficult because productivity, national product, income and other economic time series are not amenable to forecast: they exhibit non-stationarity. The second difficulty for using traditional approaches is that the effect of Bayh-Dole on economic growth is dependent in direction and magnitude of an array of other economic and S&T policies including monetary policy, trade policy, tax a subsidies to industry, and particularly the allocation of research funding across sectors of the economy.

In light of these difficulties, the theoretical framework of evaluation advanced here takes a heterodox approach. This departure from the cannon draws heavily from Public Value Mapping (henceforth PVM), a conceptual model developed by Barry Bozeman (2003) and his colleagues known. PVM is not so much an evaluation method as it is a tool of analysis for the systematic understanding of societal outcomes derived from knowledge production. Surely, this paper is concerned with societal outcomes that resulted from actions taken in response to policy not actions taken to produce knowledge. Notwithstanding the different nature of these two causes (policy as opposed to knowledge production), a case is made here to demonstrate that PVM can be used for policy evaluation. Accordingly, the purpose of this paper is twofold: (i) to develop a general framework for policy evaluation using Public Value Mapping, and (ii) to build, upon this framework, an evaluation program for the Bayh-Dole Act.

Section 2 is dedicated to adapting the main concepts and processes of PVM to policy evaluation and Sections 3 and 4 develop the evaluation program of the Act. Section 3 reviews the policy

[1] Henceforth simply "Bayh-Dole" or "the Act"

context in which Bayh-Dole was formulated, a brief history of the Act, and the influence of such a context and history to lead to congressional consensus around two public values: *knowledge diffusion* as an instrumental value and *national competitiveness* as an intrinsic value. Section 4 introduces principal-agent theory to relate the public values of Bayh-Dole to its outcomes. Under this light, Section 5 applies the criteria of public values failure suggested by Bozeman (2002, 2007) and together with principal-agent theory proposes the evaluation program of Bayh-Dole.

2. Public Value Mapping

Mapping public values into outcomes is a *process* to analyze, and possibly measure, what Bozeman (2002, 2007) calls a *public value failure*. Such a failure occurs when neither the public nor the private sectors–government and markets–provide goods and services that advance certain public values. Bozeman (2002) proposes basic *criteria* for this analysis that arguably encompasses the important dimensions in which public value failure may occur. To understand the PVM process and the criteria to assess public value failure it is appropriate to discuss the conceptual parameters to be used in this paper.

The definition of value used here is the following:

Definition 1. "A value is a complex and broad based **assessment** of an object, or **set of objects**… characterized by both cognitive and emotive elements, arrived at after some deliberation, and, because a value is part of the individual's definition of self, it is not easily change and it has the potential to elicit action" (Bozeman, 2007, p. 117[2]).

Because the concern of this paper is to develop a theoretical framework for empirical research, a foremost concern here is to render values observable. Accordingly, and within the starting definition of value at hand the *set of objects* is hereby defined as the set of known and available *policy alternatives*. Moreover, the *assessment* of such a set of policy alternatives is defined here as a *rational preference relation*; rational here simply means a preference relation that is transitive and complete[3].

Therefore, it is here posited the following definition:

Definition 2. A value is a rational preference relation over a set of policy alternatives.

Admittedly narrower, this second definition enables a formal representation of values. While a preference relation is unobservable, once a policy alternative is chosen the values that motivated such a decision can be inferred *ex post facto* because that choice is in fact observable.

Value could alternatively be defined as a rational preference relation over the set of *policy outcomes*, not alternatives. This definition however is misguiding because it does not keep

[2] Original in italics, emphasis in bolds supplied here.

[3] Complete means that for any two alternatives, an individual always knows whether one alternative is at least as good as the other, or whether she is indifferent between the two. Transitive means that of any three alternatives x_1, x_2, and x_3, if: x_1 is at least as good as x_2, and x_2 is at least as good as x_3, then: x_1 is at least as good as x_3.

outcomes analytically separated from values. This separation is crucial if is to be accepted that predicting the future bears irreducible uncertainty. It is reasonable to expect that a good decision maker considers predicted outcomes before adopting a given policy alternative, but even with reliable predictions decisions have to be made under uncertainty. Values are not only embodied in those wished for policy outcomes but also in a myriad of other considerations (generally principles), the total of which motivate policy choice. When uncertainty can be reasonably reduced, decision makers may defend consequentialism; yet when uncertainty is too great they may appeal to principles rather than consequences to make a decision. Therefore, the full measure of a value can only be inferred from the set of policy alternatives and not from the set of policy outcomes.

There are at least two difficulties related to inferred values as suggested above. First, the set of policy alternatives needs to be reconstructed as it was *ex ante facto*. For a *unique set* of policy alternatives the reconstruction of the set is an exercise in history. The difficulty in this case will be to correct for the self-serving bias of record keepers. The record of the decision maker will tend to recast the set such that the chosen alternative is justified; the record of the critic will instead describe the set such that the decision was an obvious mistake. In turn, for a *standard set* of policy alternatives, the menu of choices is the same for different decision makers (cross sectional analysis) or at different periods in time (times series analysis). As opposed to a unique set that must be excavated, a standard set will be closer to the surface. A standard set will more reliably be identified when (i) the decision makers confronting it are in competition with each other, (ii) different choices were made at one time by different decisions makers, or at different times by the same decision maker.

The second difficulty arises when policy choice is made as a means to an end[4]. Dealing with this difficulty requires to further refine the concepts. Bozeman (2007) discerns values as either *intrinsic value*, an "end state of preference" (p. 119-120) or *instrumental value*, only "valued in relation to an intrinsic value" (ibidem, p. 120). As suggested this far, instrumental values can be inferred from the policy choice they motivate, but we ought to expect that intrinsic values as well could be inferred. If intrinsic value V_o motivates instrumental value V_x, which in turns motivates the choice of x_i (x_i is an alternative of the set X), by observing x_i we may infer not only V_x but V_o as well. The difficulty arises when x_i induces a subsequent alternative set Y and only in hindsight it becomes evident that neither y_i of Y can advance V_o. Any putative V_o inferred from policy y_i will be a distorted version, if not a contradictory one, of the actual V_o. The solution to this problem is two fold, (i) to have the consecutive sets of policy alternatives X and Y well defined, and (ii) to count with a plausible explanation the outcomes the result from Y[5]. In this way the inference of V_0, V_x, and V_y can be worked out by backward induction. Again, the sets X and Y can more reliably be identified for standard sets and not unique sets of policy alternatives.

[4] Above values were described as the sum total of considerations that motivate the choice of a policy alternative. These are considerations of consequence and of principle. When speaking of an end as a motivation of the choice of means, it is implied that (i) considerations of consequence are dominant (low uncertainty of prediction) and (ii) those means are plausible causes of those ends (low uncertainty of causality).

[5] In a formal sense it is enough to have a causal explanation for a non-empty subset of Y with an outcome consistent with V_0 and not causal explanations for all the alternatives of Y.

With these conceptual parameters it is possible to deploy PVM as a policy evaluation tool. That is the goal of the subsequent sections.

3. Public Values in Technology Transfer Policy

This section discusses the context in which Bayh-Dole was passed to understand the articulation of values of that act.

3.1 Competitiveness histrionics.

The US economy was shaken during the seventies and eighties. The economic and social turmoil of the seventies raised questions about the robustness of the economy among consumers, businessmen, and government officials. This general apprehension was compounded by the deficit in the balance of trade that started in 1982. Visible sectors, i.e. motor vehicles, electronics and textiles, exhibited deteriorating trade balances suggesting a loss of international competitiveness, and higher import penetration suggested these industries were also losing their competitive edge in the domestic market. This environment fueled a wide spread concern that was articulated by media and policy makers as a national competitiveness crisis.

Empirical studies that measured competitiveness in different ways share their skepticism about the existence of the alleged crisis (see for a discussion Papadakis, 1994, and Johnson, and Chinn, 1996). If, as it seems, there was not such a competitiveness crisis, why then competitiveness became such a pervasive concern among lawmakers? On the one hand, there was a real economic problem during the seventies and eighties: very modest productivity gains led to sluggish economic growth. On the other hand, and perhaps the most enduring reason for the articulation of competitiveness as a problem, the term ‘competitive crisis’ provided media commentators and public officials with both a plausible diagnosis (it pointed to a domestic complacency with the wealth achieved in preceding decades), and suggested pathways to a solution (a package that included innovation policy).

Shrewd policy analysts and policy makers may have realized that competitiveness was an empty rationale but they knew as well that they could advance policies in its name that would seek to address the real problems: productivity and economic growth. In these cases the motive of competitiveness is a surrogate of economic growth.

3.2 Brief history of Bayh-Dole.

The proper name of the Bayh-Dole Act is the Patent and Trademark Amendments Act of 1980 (Public Law 96-517). As such, it is grounded legally in the US Constitution and philosophically in the doctrine of Intellectual Property Rights (IPRs) that recognizes legal persons the right to ownership of ideas and to profit from them. The issue at stake is at least as old as the post-war debates on S&T policy between Vannevar Bush and Senator Harley Kilgore. Bush argued that inventors had the rights to their discoveries regardless of the funds that supported their research; Kilgore in turn contended that the government best served the public interest by retaining its rightful part on publicly funded research.

Before 1980, no federal policy had settled the debate and the inevitable cost was legal ambiguity. Particularly uncertain were situations when discoveries emerged from two (or more) research programs, both jointly funded by federal and non-federal agencies, or discoveries that resulted from collaborations between public and private organizations that only in part had benefited from knowledge produced with public monies. The lack of a unified legal framework regarding patenting policy forced federal agencies to adopt independent policy solutions, 26 in total, that shifted quickly in the direction of the dominant view of the day.

The Department of Health, Education, and Welfare (HEW) that funds the National Institutes of Health (NIH), epitomizes this history of those shifts and policy reversals. After the war, universities had been allowed to license compounds developed by NIH-funded research to pharmaceutical firms, sometimes on exclusive basis. When the practice was denounced, HEW required in 1962 that firms screening such compounds commit not to obtain exclusive rights on the compounds. HEW was then criticized in the reports of the Federal Council for Science and Technology (1968) and the General Accounting Office (1968) for introducing such restrictions. In consideration to the parallel recommendations contained in both reports, HEW instituted in 1968 the Institutional Patent Agreements (IPAs) to grant universities with technology transfer capabilities ownership of discoveries emerging from agency's research grants. The National Science Foundation followed suit and implemented and IPAs program in 1973, and the Department of Defense had already started a similar program. Yet, in 1977 HEW's own General Council Office reported that the IPAs, and particularly exclusive licenses, possibly lead to non-competitive pricing of medicine. HEW was again forced to reconsider its policy and announced a review of the IPAs program. This time the reaction came from the legislative power. Senator Robert Dole (Republican) strongly criticized any move to curtail the IPAs program and together with Senator Birch Bayh (Democrat) introduced to the Senate in 1978 a bill to preempt any such policy reversal.

The Bayh-Dole Act seems modeled after the IPAs scheme with noticeable exception in the absence of qualification requirements for universities to demonstrate technology transfer capabilities and the no mention of the government preference for non-exclusive licenses.

Bayh-Dole received overwhelming approval from lawmakers in both the House and the Senate, and passed swiftly into law in 1980. Sampat (2006a) suggests that such an unusual agreement was reached because the Act focused on granting patent rights for non-profits (universities) and small businesses and included provisions that precluded "'profiteering' at the expense of the public interest" (ibid, p. 64). In fact, the original text of the Act included a provision for the government to recoup a portion of the license income, stated the government preference for licensing to small business, and limited the length of exclusive licenses granted to large business. Regrettably, none of those provisions came into full force and effect. The recoupment provision was dropped form the final text of the Act, and even the time limitations for exclusive licensing to large business were lifted in the Trademark Clarification Act of 1984 (Public Law 98-620). Third, and most importantly, the widespread concern about competitiveness that prevailed since the 1970s aided in the swift approval of the Act (see for a discussion Sampat, 2006). The congressional hearings that preceded the passing of the Act, and the statements in the floor of the

House and the Senate were reiterations of the faith in technological innovation to foster economic growth and the need to amend IPRs law.

3.3. Public Values in Bayh-Dole.

In order to identify the public values that motivate policy the text of the policy itself is a first point of reference. A reality of democratic rule is that the text of the law is generally ambiguous about public values because it emerges from negotiation and the compromise at which the deliberating parties arrive; a point formalized for long by Pendleton Herring (1936|1967). Bayh-Dole however, as described in the previous section, enjoyed little opposition. For this reason, the text of the act is not only the first but the foremost point of reference for the public values that motivated the policy.

Table 1. Public values in the Bayh-Dole Act.

Public value	Text of the Bayh-Dole Act
Promote knowledge utilization	"to promote the utilization of inventions arising from federally supported research or development"
Incentives for small business	"to encourage maximum participation of small business firms in federally supported research and development efforts"
Promote university-industry collaboration	"to promote collaboration between commercial concerns and nonprofit organizations, including universities"
Promote free markets	"to ensure that inventions made by nonprofit organizations and small business firms are used in a manner to promote free competition and enterprise without unduly encumbering future research and discovery"
Promote commercialization of knowledge	"to promote the commercialization and public availability of inventions made in the United States by United States industry and labor"
Protect the public of use/misuse of knowledge	"to ensure that the Government obtains sufficient rights in federally supported inventions to meet the needs of the Government and protect the public against nonuse or unreasonable use of inventions; and to minimize the costs of administering policies in this area"

Source: Patent and Trademark Amendments Act of (Public Law 96-517).

It can be seen in Table 1 above, Bayh-Dole states its purposes as: the promotion of *knowledge utilization* and *commercialization*, and the promotion of *university-industry collaborations*. It also refers to the provision of incentives for free competition and participation of small

businesses in the market of innovation. This language points in a clear direction: Bayh-Dole sought to improve the process of knowledge diffusion by legitimizing the appropriation of intellectual property of knowledge produced with federal funds.

Advocating the transfer and commercialization of knowledge reflect the public value of *knowledge diffusion*. Transfer and commercialization are only means to increase productivity and bolster economic growth, two outcomes that reflect another public value: *national competitiveness*. Knowledge diffusion is then an instrumental value and national competitiveness is an intrinsic value. It could be argued that competitiveness is an instrumental value of a deeper intrinsic value, social well-being, but the abstraction of well-being would take us too far apart from the scope of evaluation of technology transfer.

Twenty years after it was passed into law, the public values of Bayh-Dole were still clear in the minds of the bureaucracy that implemented it. Exemplar of this point is the statement of Maria Freire, Director of the NIH's Office of Technology Transfer, at congressional hearings of the House Appropriations Subcommittee on Labor, Health and Human Service, Education and Related Agencies, said in August 2001:

> "The goal of these laws [technology transfer laws] is to promote economic development, enhance U.S. competitiveness and benefit the public by encouraging the commercialization of technologies developed with federal funding."

The next section introduces a causal model to examine the causal links between policy the identified public values and the outcomes of the Bayh-Dole Act.

4. Bayh-Dole as a solution to moral-hazard

The relationship between government and science has been theorized as a relation of delegation where the government, as principal, funds the agency of science to generate innovation (Guston, 1996, 2000) that, at least a priori, is expected to bring about broad social benefits. This principal-agent relation presents a problem of moral hazard for the principal because the government cannot tell if the research institutions are performing or shirking. A standard solution for this problem is for the principal to monitor the agent. Monitoring science however is not inexpensive and turns moral hazard into a recursive problem (who watches the watcher?). Another solution to moral hazard is to implement a contract between principal and agent that lines up the interests of the agent to those of the principal. The contract is a mechanism compatible with an incentive for the agent to further the interests of the principal while it advances it own interests.

As seen above, the proponents and defendants of Bayh-Dole believe that granting property rights to research institutions for them to profit from their inventions ought to be sufficient incentive for them not only to be diligent in producing innovation, but producing the type of innovation valued by society, with a high commercial value. Under such a logic, Bayh-Dole works as an *incentive compatible mechanism*. Like *stock options* in a compensation package offered to a firm's chief executive officer, the government is offering to research institutions the legal right to all *future incomes* from innovation. The chief executive has the incentive to maximize the long-term profit of the firm because, by doing so, he maximizes the redemption value of its options. Similarly, under Bayh-Dole, research institutions have the incentive to produce innovation of

high social value, because if the markets value such innovations highly, those institutions cash in handsome licensing incomes.

As a contract nevertheless, Bayh-Dole is generous with research institutions, because without a recoupment provision, no portion of the funds given in research grants are expected to be repaid to the government. This is analogous to a board of directors so content with keeping the good name of their firm that they would grant the chief executive all rights to future profit produced under his administration. One thing is clear from this comparison: publicly held companies are much harder to run than representative democracies, because the directors of our hypothetical firm would loose their seats at the board not too long after stockholders find that all dividends on their holdings were forever forgone.

Regardless of how generous an incentive is Bayh-Dole (which should be decided by the electorate), if conceding legal rights to any portion of future licensing incomes is in fact an incentive, then conceding all incomes is as much an incentive as can possibly be built-in this type of contract. The question is whether the contract is compatible to an incentive. An affirmative answer means that scientists will maximize their utility by exercising maximum effort in fulfilling the mandate of their research grants. But, Bayh-Dole as a contract was tendered without conditions; future incomes are promised to research institutions without requiring from them any assurances of productivity. The chief executive was given all future profits regardless of the size of those profits. What would happen if he can afford a very comfortable life with his fixed salary? Probably, he would care little about the appreciation of his options. Likewise, if the contest system for research grants was not changed, Bayh-Dole could not be much of an incentive and researcher's attention would remain competing for research grants to guarantee funding for their preferred research and a decent livelihood.

In addition to the risks associated to an unchanged contest system for research grants (equivalent to a fixed salary scheme), the researcher's subjective probability of producing a profitable patent is crucial to determining whether the contract is compatible with an incentive. In effect, the lower a researcher believes is that probability, the lesser incentive is derived from Bayh-Dole. Again, a chief executive does not find stock options to be a true incentive if he will be hired to rescue a troubled firm with a bleak financial future. Consider the learning curve of knowledge as a function of research effort, and the probability of producing a profitable patent θ as a function of knowledge (both functions convex–marginally decreasing returns–and singled valued). If the marginal increase of the probability of producing a profitable patent is small for any marginal increase of knowledge, it doesn't matter much the amount of additional effort put in to research; the probability of profit is not an incentive to increase research efforts, rather, these conditions may even elicit shirking. Still, if the marginal probability is high, and the contract works, only a fraction of the total patent profit is necessary to elicit maximum effort from scientists, the government is forgoing income that could have alternative use in the furtherance of the public interest. Again, in the analogy of the firm, the contract must tie compensation to long term profits but if any fraction of profits γ can be effective, committing all profits to the contract would be giving away $1-\gamma$ of profits. Proponents of a Bayh-Dole scheme may argue that since that fraction is hard to estimate, it is better to give all away in order to signal the government's good will, but such argument does not change the fact that there is a social cost of such an obsequious contract when $\gamma<1$.

5. Public Failure in Technology Transfer

The conceptual and explanatory tools introduced so far can now be deployed as a theoretical framework for the assessment of technology transfer policy.

As discussed above, Bayh-Dole could be understood as a contract that introduces the incentives for research institutions to produce innovation of commercial value. In the scheme of public values failure suggested by Bozeman (2002, 2007), this is a contract that seeks to shift the system of research and development away from a situation of *market failure*. Innovation is of course assumed to be a public good. The classic economic argument explains that the further research is from development (in the R&D process), the greater is the uncertainty of research to produce commercial applications, and the less likely are private firms to invest in research because their expected return is not necessarily non-negative. Thus, free markets under-provide research, and especially basic research with respect to its socially optimal level. This market failure is resolved when the government secures the optimal provision of research funds (Nelson, 1959, Arrow, 1962). If Bayh-Dole works then effectively as an incentive, research institutions will justify their research in terms of their potential applications, and even perhaps rebalance their research agenda towards applied sciences, engineering, and development. At the same time, it would be expected that the expected return of the private sector for investment in research will increase, not only because effectively the uncertainty of profitable applications is reduced, but because researchers provide more information about possible uses. If Bayh-Dole works then as an incentive compatible mechanism, the R&D system should shift away from market failure towards what Bozeman calls *market success* (2002).

Public values failure nonetheless may occur when markets run efficiently. If Bayh-Dole effectively operates as suggested above, it provides incentives for increasing research with a commercial value, which is not necessarily research of social value. The commercial value of a technological application may be high simply because it serves a market segment with great purchasing power, and not because it satisfies a need widely spread through society. Particularly, when wealth and income are distributed unequally, business placing new technologies in the market may find that catering some segments of society is more profitable than broad based introductions of the same technologies. For instance, the demographic changes that will start to take place in the next decade will increase the demand for services for aging people and the elder, particularly in the healthcare industry. It is also known that, as a demographic group, the babyboomers have accumulated unprecedented wealth. If Bayh-Dole has worked appropriately, research institutions anticipating this increasing demand, would have increased their patenting activity of medicine and medical treatments and devices to treat people of advanced; Bayh-Dole may have effectively reallocated the research agenda away from younger demographic groups. Other profitable markets may simply be driven by fashion (non-resconstructive aesthetic surgery) or idiosyncratic preferences (videogames, large screen TVs). In summary, even if Bayh-Dole worked effectively as an incentive compatible mechanism, and dealt to some successful measure with the market failure of the research and development system it may be fraught with public failure.

Another source of market failure is the opportunity social cost when the proportion of licensing income that the government ceded was lesser than 100% of the ($\gamma<1$). These are public monies forgone in favor of monopolies seizing profit. The argument that technological monopolies are necessary to commercialize innovation is plausible. But it cannot be said that a government participation in the profits of such monopolies would trump the ability of firms to develop technologies.

Bayh-Dole is ultimately implemented by offices of technology transfer (OTTs) at universities and other research institutions that benefit from the Act. The menu of options that they confront is a standard set of policy alternatives (e.g. file in for a patent or not, license exclusively or not, license to small firms or large corporations). As suggested in Section 2, the values of knowledge diffusion and competitiveness can be compared against the systematic adoption of particular policy choices by these OTTs. Furthermore, these choices will produce outcomes that can understood to the light of the explanatory model provided of principal-agent introduced in Section 4, and mapped into public values failure scheme discussed in Section 5. Some outcomes will be consistent with public failures, while other with public successes. There cannot be a final verdict on Bayh-Dole, and any attempt to produce one may err of simplistic. But the assessment within the framework proposed here will shed some light into the conditions that produce public failures, and be used as a guidance for improving the design, formulation, and implementation of technology transfer policy.

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