Unit 16

TITLE: THE TECHNOLOGY PORTFOLIO CONCEPT

PURPOSE: This unit provides a general introduction to technology portfolio management and its underlying concepts.

OBJECTIVES: Upon completion of this unit, participants will:

- Have acquired a basic understanding of the concepts of opportunity cost, risk, and return as they relate to a general decision-making framework for the investment of laboratory resources in technology transfer opportunities
- Have been introduced to conceptual mechanics and the benefits of managing time and money investments in technology transfer opportunities within a technology portfolio.

MATERIALS:

Transparency 16-1:	The Technology Portfolio Concept
Transparency 16-2:	Fundamentals
Transparency 16-3:	What Are We Trying To Accomplish?
Transparency 16-4:	Choice
Transparency 16-5:	Opportunity Cost
Transparency 16-6:	Risk and Return
Transparency 16-7:	Putting the Concepts To Work
Transparency 16-8:	A Technology Portfolio
Transparency 16-9:	Costs and Returns From the Lab Perspective
Transparency 16-10:	Summing Up

REQUIRED READING: None

OPTIONAL READING: None

NOTES TO INSTRUCTOR:

1. The underlying concepts of opportunity cost, risk, and return are essential to understanding the fundamentals of portfolio management; however, these concepts also have a much broader and perhaps even more important application as tools that promote a better understanding of the consequences and implications of making choices.

2. The text of this unit has a private sector investment decision orientation because:

   a. These concepts are most commonly used and understood in finance and investment applications; and

   b. Private sector players are often going to assess their involvement with Federal labs in technology transfer activities in these terms.

3. It is anticipated that the value of this instructional unit will be much greater for those individuals who have acquired some experience in transferring technology to the private sector. In this sense, the presentation of this unit should be considered optional, depending on the knowledge level of the audience.

4. This unit further explains and extends a number of portfolio management points made in Unit 15 (Classifying, Evaluating, and Managing Technologies for Transfer).

ESTIMATED TIME:

25 minutes for presentation
45 minutes with discussion

Unit 16

THE TECHNOLOGY PORTFOLIO CONCEPT

Transparency 16-1: The Technology Portfolio Concept

NOTE: PRESENT PURPOSE AND OBJECTIVES OF THIS UNIT.

INTRODUCTION

This brief discussion will focus on an application of basic portfolio theory as a commonsense conceptual approach to evaluating and managing technology transfer opportunities. It will further explain and extend a number of portfolio management points made in the preceding unit. The approach and its underlying concepts are offered not as a mathematical decision-making tool (as is most often done), but rather as a way to organize thinking when pondering choices concerning the deployment (investment) of laboratory resources (including time) under uncertain conditions. The innovation process is permeated with choices and uncertainty. The discussion outlines a "way of thinking" that may be of some value when there are choices to be made in investing time, money, or effort into some activity (including, of course, technology transfer activities).

This discussion is important for another reason. Private sector players, either explicitly or implicitly, generally think in these terms when evaluating a technology transfer opportunity. Effective communication and negotiation based on an understanding of private sector motivations and behavior can substantially enhance your private-sector-oriented technology transfer efforts.

What we would like to accomplish in this discussion is to pin down the basic concept, apply it, and then urge you to include it in your perspective as you participate in making choices within innovation processes involving transfer.

FUNDAMENTALS

Transparency 16-2: Fundamentals

A portfolio is simply a combination of assets. For the purposes of this discussion, let's define assets very broadly as resources or advantages. The premise of portfolio theory is that the riskiness inherent in any single asset held in a portfolio is different from the riskiness of that asset held in isolation. The idea is to turn that difference to your advantage. Keeping this rather general premise in mind, let's get a little more specific.

> NOTE: IT IS IMPORTANT TO STRESS THAT "ASSETS" IS BEING BROADLY DEFINED AS "RESOURCES." "RESOURCES" IS ALSO BROADLY DEFINED AS "AVAILABLE MEANS TO ACCOMPLISH SOME OBJECTIVE."
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> NOTE: "BASIS OF PORTFOLIO THEORY" IS PRESENTED AT THIS JUNCTURE AS A MEANS OF PREVIEWING THE PRIMARY EDUCATIONAL OBJECTIVE OF THIS UNIT. THE REMAINDER OF THIS PRESENTATION IS INTENDED TO BUILD TOWARDS A GENERAL UNDERSTANDING OF THIS STATEMENT AND ITS IMPLICATIONS.

OBJECTIVES

Transparency 16-3: What Are We Trying To Accomplish?

> NOTE: THE INTENT HERE IS TO ACKNOWLEDGE THE THEORY BUT TO EMPHASIZE THE PRACTICAL OBJECTIVE, WHICH IS TO MANAGE RESOURCES IN COMBINATION TO REDUCE RISK OR INCREASE RETURN.

What are we really trying to accomplish? Well, in theory, it's the quest for the optimal portfolio. At any point in time we are trying to obtain the highest possible return for any specified degree of risk or the lowest possible risk for any specified rate of return.

In practice, we're saying, "I've got some resources, and I'm going to use the ones that I think will best allow me to accomplish X. I want to do this in a way that will reduce the likelihood of coming up short."

Another way of saying this is that one should have the presence of mind to evaluate and manage investments as a well-conceived combination in order to increase the return and/or decrease the risk of the total investment at any point in time.

Additionally, new investment opportunities should be evaluated in terms of their impact on the overall risk and return associated with other combinations of assets or potential investment opportunities.

KEY CONCEPTS

Now let's explore some of the key concepts behind this way of thinking.

Choice

Transparency 16-4: Choice

First and always is "choice." Remember, there's no such thing as a free lunch. Everything you do has its cost. When you choose to have more of one thing, you are also making a decision to have less of something else. This is obviously true when you've just got five bucks in your wallet; but it applies to much more than this; it holds for everything you do.

Opportunity Cost

This leads to the second key concept: opportunity cost.

Transparency 16-5: Opportunity Cost

The Chinese proverb on the transparency is a simple way of capturing the essence of opportunity cost and suggests another principle: where there is gain, the loss is not obvious.

Let's look at a small example. You've got some free time. There are two things you'd like to do, but you can't do both. Let's say you either want to read a book or watch T.V., and you decide to read a book. The cost of reading the book is foregoing the enjoyment you would have received from watching T.V. However, you must also keep in

mind that the enjoyment you would have received from watching T.V. (the return foregone) might have been greater than or less than the enjoyment you did receive from reading a book.

Here's a more formal definition of opportunity cost: the cost of using something in a particular venture is the benefit foregone (opportunity lost) by not using it in its best alternative use. Notice that the definition specifies "best alternative use" as opposed to "next best alternative use." This is because sometimes we don't make the best decision; that is, the benefit foregone is greater than the benefit actually received.

As we participate in the technology transfer process, we will have the opportunity to make many choices, using dollar signs as a common language. Some of them will be $100 choices, some may be $1,000,000 choices. The cost of these choices will be measured by the best "other" use of that money.

The notion of "opportunity cost" is a useful tool for putting choices in perspective, and it's a basic principle underlying the use of portfolio management to cope with investment decisions under uncertain conditions.

NOTE: THE CONCEPT OF OPPORTUNITY COST IS A VALUABLE AID IN UNDERSTANDING THE CONSEQUENCES OF DECISION-MAKING. IT IS USED WHEN TRYING TO DECIDE IF, WHEN, AND HOW MUCH TIME, EFFORT, AND/OR MONEY TO COMMIT TO A PARTICULAR COURSE OF ACTION. IT WOULD BE HELPFUL TO USE ADDITIONAL EXAMPLES BASED ON TYPICAL TIME COMMITMENTS OR PERSONNEL DEPLOYMENT DECISIONS THAT ARE ADDRESSED EVERYDAY WITHIN THE LAB, ESPECIALLY IF THEY INVOLVE A PERCEIVED CONFLICT OF COMMITMENT. FOR INSTANCE, A PROGRAM MANAGER MAY HAVE TO MAKE A CHOICE BETWEEN ALLOWING A SCIENTIST TO CONTINUE WORKING FULLTIME ON A PRIMARY MISSION TASK OR ENABLING THE SCIENTIST TO WORK COOPERATIVELY WITH A PRIVATE SECTOR ORGANIZATION. ASK THE PARTICIPANTS WHAT THE OPPORTUNITY COSTS ARE THAT ARE ASSOCIATED WITH SUCH A DECISION.

Risk and Return

Transparency 16-6: Risk and Return

> NOTE: IT IS IMPORTANT AT THIS POINT TO MAKE THE TRANSITION FROM SPEAKING IN TERMS OF BENEFIT TO SPEAKING IN TERMS OF RETURNS, KEEPING IN MIND THAT RETURN DOES NOT IN ITSELF MEAN "MONEY" RETURN. WHEN WE SPEAK IN TERMS OF RATE OF RETURN OR MONEY RETURN, IT IS BECAUSE WE ARE USING A PRIVATE SECTOR INVESTMENT PERSPECTIVE.

Two other concepts of importance are risk and return. Risk is simply the probability of occurrence of an unfavorable outcome. Generally, it is something you want to reduce. Rate of return can be defined as the benefit you receive relative to the cost you incur. It's often expressed as a percent applied to a money investment (as in "my IRA is earning 12%" or "if our product goes to market based on this technology, I figure we'll receive an annual return of at least 45% for seven years"). In general, the greater the risk, the greater the return.

It is important at this point to mention present worth--the time value of money. The farther out in time you go, the less a dollar is worth. Would you rather have $100 today or $2,000 10 years from today? The big question here is one of opportunity cost. Could you take the $100 today and over a period of 10 years create a value greater than $2,000, and at what risk?

As a means of making logical investment decisions today, future income streams are generally reduced by using a discount rate to establish their present worth. Rather than go into the mathematics, let us just say that the discount rate takes into account the opportunity cost associated with the income stream. It works like a compound interest rate in reverse.

By way of illustration, let's select royalties from the array of possible benefits or returns that the lab could receive from its technology transfer activities. Let's say you have 1,000 hours in laboratory personnel time that you can commit to assisting in prototype designs for private sector concerns and you have a choice between two companies (and two different technology-based products). Let's assume

the lab would receive a royalty position on either product and these rates would be the same. Product A has an anticipated revenue stream (upon which the royalty would be based) of $20 million distributed equally over five years, and product B has a $28 million anticipated revenue stream over 10 years with 40 percent of the earnings coming in years seven and eight.

To make this decision, you would need to compare the present value (the value today) of these future royalty streams to see which is greater. This is accomplished by selecting a discount rate and using a standard present value formula to establish how much these anticipated earnings streams are worth to you today.

This is the way these decisions are commonly made. Although the procedure sounds fairly precise, projecting earnings and selecting discount rates are by their nature speculative and often arbitrary. Estimating present value generally forces you to focus on an intended product with a particular earnings potential and life cycle. This often causes an undervaluing of the technology that forms the basis of the products, which in fact may have much greater value than the product it is embodied in.

APPLICATIONS

Transparency 16-7: Putting the Concepts To Work

Now let's begin to put some of these concepts to work within a portfolio context--first specifying a few terms that I'm sure most of you are familiar with.

We'll define correlation as the relationship between two variables. Using anticipated rates of return for two technology transfer projects as the two variables, let's identify three points in order to define a continuum.

The first point is negative correlation, which means over time when the rate of return for project A is high, the rate of return for project B is low and vice-versa.

Next is uncorrelated. This is when there appears to be no relationship between the rate of return for project A and the rate of

return for project B. Their behavior relative to each other is unpredictable.

And finally, positive correlation. Over time when the rate of return for project A is high, the rate of return for project B is also high and vice-versa.

Let's look at an example in which we can apply these concepts.

NOTE: SINCE THESE MATERIALS ARE ORIENTED TOWARDS TECHNOLOGY TRANSFER TO THE PRIVATE SECTOR, THIS EXAMPLE LOOKS AT LAB TRANSFER OPPORTUNITIES THROUGH A PRIVATE SECTOR PERSPECTIVE. THE WORD "RETURN" IS USED INSTEAD OF "BENEFIT."

Let's assume we have identified the type and/or level of return we are after and are analyzing some technology transfer opportunities that will require substantial but approximately equal amounts of lab time and money. All of our choices appear to have the capacity to deliver a return that exceeds what we are willing to accept; but they are all fairly risky, and we do run the chance of coming up with nothing but costs. Going back to our original premise, what we want to do is use portfolio concepts to deploy our resources in a manner that will get this rate of return but will reduce our risk (i.e., reduce the probability of an unfavorable outcome).

How does this work? Let's jump to the end.

Let's say that as part of the analysis we've identified the products that the array of technology transfer opportunities could lead to. We've also identified the industries with which these products are associated and the historical behavior of the rates of return in these industries. Based on this information, we recommend that the lab invest its resources to advance ongoing work in two areas: the development of a technological innovation for microcomputers and participation in prototype development for a new material specifically destined for the residential construction industry.

Here's the reason for the recommendation.

Transparency 16-8: A Technology Portfolio

> NOTE: THIS HYPOTHETICAL EXAMPLE IS INTENDED TO ILLUSTRATE THE VALUE OF USING TECHNOLOGY PORTFOLIO CONCEPTS WHEN MAKING DECISIONS ASSOCIATED WITH COMMITTING LAB RESOURCES TO TECHNOLOGY TRANSFER OPPORTUNITIES. A MORE RIGOROUS THEORETICAL AND MATHEMATICAL EXPLANATION CAN BE FOUND IN MOST FINANCIAL MANAGEMENT TEXTBOOKS. IN ADDITION, THE INSTRUCTOR MAY FIND IT HELPFUL TO DEVELOP LAB-SPECIFIC EXAMPLES.

When the economy is robust, the demand for microcomputers is high; when the economy is depressed, so is the demand for microcomputers. On the other hand, demand for residential construction tends to be countercyclical; that is, when the overall economy is depressed, the demand for construction materials tends to be high and vice-versa. This is because the demand for residential construction is heavily influenced by the availability of credit. When the economy is booming, interest rates are usually high, and high interest rates apparently discourage potential home buyers more than they discourage other demanders of credit.

These two choices represent a good combination because of the divergent cyclical patterns of their rates of return. When taken in combination, the net effect is that the anticipated return will be much more stable and less risky. Risk has been reduced through diversification.

Going back to some previous terms, when one anticipated return is high and the other is low, they are negatively correlated. When two projects have a high degree of negative correlation, making and managing the investments in tandem will reduce the overall risk. This is illustrated conceptually in the diagram on the lower half of the transparency, which shows the combined effect of the two hypothetical investments. This risk reduction is defined as portfolio effect.

If, on the other hand, these two projects exhibited a high degree of positive correlation, overall risk would not have been significantly reduced through diversification.

Here's another important point. If the returns from the two projects were completely uncorrelated, diversification would still be of some benefit. The larger the number of independent, or uncorrelated, projects in which resources are invested, the smaller will be the variation in the overall rate of return. Uncorrelated projects do not have as big an impact on reducing risk as negatively correlated projects. Nonetheless, they are preferable to positively correlated projects and can substantially reduce risk if available in sufficient numbers.

In reality, most projects will be positively correlated because their performance is often influenced by the same economic factors. This will certainly be the case if technology transfer efforts are directed towards commercialization activities in one industry.

Once you know what you're trying to accomplish (once you know your target return), you can reduce the probability of unfavorable outcomes by putting your resources to work in independent projects. Many of these concepts can be mathematically extended and systematically applied as decision tools. However, in this discussion we are simply suggesting that you introduce these concepts into your decision-making perspective.

It is also very important to stress that we are not necessarily speaking about different and independent technological possibilities or technologies. A technology or a technological possibility, when stripped of its real or envisioned product embodiment, may have substantial value through a series of applications within a number of relatively independent markets.

COSTS AND RETURNS

Since we've been discussing decision-making perspectives for investing lab resources, it's best to take a minute to acknowledge costs and returns from the lab's perspective.

Transparency 16-9: Costs and Returns From the Lab Perspective

NOTE: IT IS ONCE AGAIN IMPORTANT TO STRESS THAT THE CONCEPTS OF OPPORTUNITY COST, RISK, AND RETURN DO NOT JUST APPLY TO FINANCIAL INVESTMENT DECISIONS. THESE CONCEPTS CAN BE EFFECTIVELY EMPLOYED ANYTIME AN INDIVIDUAL DECIDES TO COMMIT RESOURCES (INCLUDING TIME AND EFFORT) TOWARD A PARTICULAR COURSE OF ACTION.

Included among the resources that will be committed are time, money, effort, and equipment. The value of these resources becomes readily apparent when you think in terms of opportunity cost.

When the investment goes to work, what are the benefits, and what are the returns? At a minimum the list should include:

- Public good aspects--enhanced innovation in the public and private sectors; strengthening international competitiveness; and increased public revenues for the provision of public services
- Market returns--money from successful innovation for laboratory personnel, agencies, labs, and the private sector
- Private (personal) returns--gratification, professional advancement, recognition, and so on.

NOTE: THESE BENEFITS REPRESENT VALUE TO THE LAB AND SHOULD BE CONSIDERED IN THE LAB'S ASSESSMENT OF THE OVERALL VALUE OF THE TECHNOLOGY.

SUMMATION

Transparency 16-10: Summing Up

In summation, the objective is to manage a group of technology transfer opportunities in combination in order to increase the expected return or reduce the risk.

Always remember, especially when evaluating a new opportunity, that a specific technology transfer opportunity may be quite risky when held in isolation but not very risky when held in a portfolio. The key

element is negatively correlated or uncorrelated rates of return on projects.

And finally, to complicate matters (but make them more interesting), technology portfolios with differing risk characteristics can be managed within a larger portfolio (that is, in combination) to reap addditional portfolio benefits.

DO THE PARTICIPANTS HAVE ANY OPINIONS ON THE CONCEPT OF THE TECHNOLOGY PORTFOLIO AND ITS APPLICABILITY TO LABORATORY PRACTICES?
