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The Total Economic Impact™ of Deploying Sun Ray™ Technology

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Executive Summary

In April of 2006, Sun Microsystems commissioned Forrester Research to examine the total economic impact (TEI) of deploying Sun's Sun Ray™ virtual display technology in an environment that had primarily PCs. This report highlights the benefits of deploying Sun Ray clients as demonstrated from the interviews and analysis of an organization using the Sun Ray solution. The report examines the estimated return on investment (ROI) for the organization and represents the findings derived from the interviews and analysis process, as well as the independent research of Forrester Research.

Purpose

The purpose of this study is to provide readers with a framework to evaluate the potential financial impact of implementing the Sun Ray virtual display solution in their organizations. Forrester's aim is to clearly show all calculations and assumptions used in the analysis. Readers should use this study to better understand and communicate a business case for investing in the Sun Ray technology.

Methodology

Forrester Research was selected for this project because of our Total Economic Impact™ (TEI) analysis methodology, which not only measures costs and cost reduction (areas that are typically accounted for within IT) but also weighs the enabling value of a technology in increasing the effectiveness of overall business processes. Forrester's TEI methodology is a way of quantifying the full impact of a technology investment by considering four elements of any initiative:

1. Benefits
2. Costs
3. Flexibility
4. Risk

Given the increasing sophistication that enterprises have regarding cost analysis related to IT investments, Forrester's TEI methodology serves an extremely useful purpose by providing a complete picture of the total economic impact of purchase decisions.

Brief Description Of The Sun Ray Thin-Client Solution

According to Sun, the Sun Ray solution is a tested, tuned and documented virtual display solution consisting of a Sun Ray client, Sun Ray Software, and Sun servers[†]. Implementations can range from a small network within a single office, to an environment where Sun Ray clients are deployed over geographically dispersed locations to multiple end-user groups. Sun Ray clients can be installed on existing networks with other types of clients, and can also be deployed over a wide area network (WAN) with computer resources secured in a central, remote location.

Because the applications, data, and operating system reside on the server, the Sun Ray client requires no administration at the desktop and a user's session is hosted and maintained on the server. This centralization of data, applications, and operating system, creates a "stateless" desktop environment that is both secure and efficient to maintain. These attributes lead to potential reductions in administrative overhead (Sun indicates that in their internal deployment they have one administrator for 2,000 Sun Ray desktops) and power consumption, since the Sun Ray 1 only consumes 13[‡] watts of electricity, versus 80 watts (typical) for a PC.

[†] Sun Ray technology can also be used with 3rd party servers.

[‡] Sun indicates that the new model of Sun Ray client, the Sun Ray 2, consumes only 4 watts (typical) of electricity.

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All Sun Ray clients have a built-in smart card reader. Smart cards can be used to enable “Hot desking,” the ability for a user to move from one Sun Ray client to another, (e.g., changing offices, going to the next building to work, etc) and gain access to the same session exactly where the user left off. Java cards can be used to provide an increased level of security with biometric authorization (biometric data is stored on the card and validated against the user), and can be used as “e-purses,” that is storing cash value on the card. At the most basic level smart cards can be used as employee badges.

Key Findings

Our research and interviews with the customer organization show that implementing the Sun Ray solution can provide benefits to organizations in:

- The ability to reduce the support and administrative costs by standardizing most users on a Sun Ray platform. Both the stateless Sun Ray client and the ability to maintain control over their environment was a large factor that drove benefits to the organization.
- The ability to create a stateless and mobile environment allowing users to switch easily and efficiently between Sun Ray clients as workers move between locations.
- The ability to set policies centrally allows the user’s environment to be minimally impacted by external threats. This, in turn, leads to minimized downtime on the end-user environment.

As part of this analysis, Forrester took data received from the interviewed organization to construct a ROI based model. The summary findings based on the model of the customer organization are as follows:

- For the organization, the risk-adjusted three-year ROI was 111% percent and the non-risk-adjusted ROI was 142% percent (see Table 1).
- Risk-adjusted payback period was within 1.1 years.

Table 1: Customer Organization Financial Summary

Summary Financial Results	Original Estimate	Risk-Adjusted
ROI	142%	111%
Payback period (years)	1.0	1.1
Total costs (PV)	(\$695,795)	(\$790,690)
Total benefits (PV)	\$1,681,388	\$1,671,441
Total (NPV)	\$985,593	\$880,751

Source: Forrester Research, Inc.

In presenting this sample organization, we hope to show the logic and calculations for an organization considering migration to a virtual display environment. The assumptions in the calculations that follow are based upon the interviews with an organization that have undergone this migration. However, it is important to remember that organizations, needs, and environments vary and the most relevant numbers are those that take your own situation into account.

From our customer interview, we have discovered the following:

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- Reduction in support around the management of an end-user device represents a significant portion of the benefits received by the composite organization.
- The impact of training on the end user environment is a key component achieving full end user end benefits. Users that are familiar with a standard network PC environment will need have a fair degree of education around the movement to a server centric environment. While this is a factor for any PC to virtual display migration, the need for training of the end users cannot be understated to achieve the expected benefits.
- Accurate planning of user requirements is another factor that can ensure benefits will be realized as expected.

ROI will vary significantly from one organization to the next. Organizations should use Forrester's research as a guide in their decision-making process when considering this or any solution.

Disclosures

The reader should be aware of the following:

- The study is commissioned by Sun and delivered by the Forrester Consulting group.
- Sun reviewed and provided feedback to Forrester, but Forrester maintained editorial control over the study and its findings and did not accept changes to the study that contradict Forrester's findings or obscures the meaning of the study.
- The customer name for the interviews were provided by Sun.
- Forrester makes no assumptions as to the potential return on investment that other organizations will receive. Forrester strongly advises that the reader should use their own estimates within the framework provided in the study to determine the appropriateness of an investment in the Sun Ray solution.
- The study is not meant to be used as a competitive product analysis.

Analysis

As previously mentioned, Forrester's TEI conclusions are derived in large part from information received in a series of interview with executives and personnel at a customer organization which has deployed the Sun Ray technology.

Forrester observed several important characteristics in the organization interviewed, including:

- The client had a heterogeneous environment prior to the implementation of Sun Ray clients, consisting of legacy client/server devices and primarily networked PCs.
- The organization interviewed anticipated a reduction in administrative and support costs, a key driver in increasing the size of the Sun Ray platform.
- The organization saw mobility of their end users as a factor to move toward a stateless client. However, access of users outside of the internal network was limited.
- Network security, both in terms of protection of the network and unauthorized access, is a critical component to ongoing operations.

From these value statements, Forrester was able to extrapolate and generate a potential ROI for an organization that is considering integrating Sun Ray clients into their existing network environment.

Interview Highlights

The interviewed organization is a value-added technical distributor of complex computer products, solutions and services. The company offers its partners support as they take complex computer solutions to market, focusing on the areas of network security, storage, enterprise applications software and the Sun Microsystems, Inc systems platform.

Following the Sun Ray implementation, the organization realized the following benefits:

- Reduced Hardware Costs
- Reduced IT Maintenance Costs
- Improved Security

Findings and Analysis

To start the analysis, we first need to describe the makeup of the organization. Table 2 provides the initial assumptions of the end-user population.

Table 2: Basic Assumptions

Metric	Total
Total Number of Users	600
Percent of workers that are mobile and/or not be migrated	40%
Percent of those users that will be migrated	60%
Net users migrated	400
Users not migrated	200

Source: Forrester Research, Inc.

From these basic assumptions, we assume that the overall end user population is roughly 600 employees. Of those 600 employees it is assumed that 40 percent will not be migrated to the Sun Ray clients. There are several potential reasons for not migrating this subset of users; these include users who are highly mobile outside of the network, or users that require only laptops. The 400 employees consisted of users that used either network PCs or virtual display clients.

From this set of characteristics, Forrester Research projected the impact of implementing the Sun Ray solution at this organization. Risk factors that would cause the actual results to vary from these estimates were considered.

Framework Assumptions

Table 3 lists the discount rate used in the PV and NPV calculations and time horizon used for the financial modeling.

Table 3: General Assumptions

Ref.	General assumptions	Value
	Discount rate	10%
	Length of analysis	Three years

Source: Forrester Research, Inc.

Organizations typically use discount rates between 8% and 16% based on their current environment. Readers are urged to consult with their finance department to determine the most appropriate discount rate to use within their own organization.

Benefits and Savings Opportunities of Implementing a Sun Ray Solution

For the organization, the following assumptions regarding the benefit estimates were made:

- The organization is transitioning from a heterogeneous environment of both virtual display clients and networked PCs to primarily a homogenous Sun Ray environment.

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- The need to control the desktop administration costs, to have a consistent security standard across the environment and to improve the mobility of users within the network.
- Desktop administration was one of the areas expected to receive savings, especially in terms of improving the overall efficiency of staff

The first component of this analysis looks at the potential benefits associated with an organization standardizing its environment onto a single Sun platform. Interviewed customers derived quantifiable benefits from standardization as the legacy systems in place were replaced by a single platform system. The benefits Forrester identified were in the form of:

- Cost savings through hardware cost avoidance.
- Improved operational and integration efficiencies.
- Improved security

This section illustrates the possible ways to quantify the impact of these benefits for the sample organization and is based on information collected during the interview process. Readers are advised to enter their own estimates to generate a potential return for their organizations.

Forrester assumes that benefits can begin to accrue in the first year of analysis (Year 1) to take into account the time to implement.

Hardware Cost Avoidance

By using Sun Ray virtual display clients, the sample organization avoided the greater cost of fat clients. The Sun Ray units are approximately half the cost of the comparable PCs the organization had formerly purchased. In calculating this benefit, a three year refresh cycle was assumed. Therefore, the benefit was estimated in each year as the cost of the PCs for one third of the Sun Ray users. This was equal to a cost savings of \$72,000 each year, for a total of \$179,053 (present value).

Table 4: Hardware Cost Savings

Ref.		Calculation	Value
C1	Number of users		360
C2	PC cost		\$600
C3	Length of refresh cycle		3 years
C4	Total savings	$C1 * C2 / C3$	\$72,000

Source: Forrester Research, Inc.

IT Maintenance Savings

Another area of savings for the organization was around its operations and support requirements for the desktop environment. The sample company estimates that up to eight additional IT staff

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would be needed to maintain the environment if the Sun Ray platform were not being used. This was primarily due to the increasing complexity and support requirements of a decentralized end user environment. At a fully burdened annual rate of \$100,000 per staff person, the total annual savings is \$800,000 by the third year – this is ramped up over the three years from 4 FTE’s (4*\$400,000) \$400,000 in the first year and 6 FTE’s (6*\$100,000) \$600,000 in the second year.

Table 5: Consolidation Cost Savings — Support

Ref.		Calculation	Value
C4	Staff reduction		8
C5	Annual salary —IT staff		\$100,000
C6	Total annual savings (Year 3)	C4*C5	\$800,000

Source: Forrester Research, Inc.

Improved Security Cost Savings

Using Sun Ray clients makes an organization less vulnerable to attack, allowing the organization to secure information at the core rather than residing locally on a user’s desktop. Using a centralized system increases the ability of the administrator to control access to the system, creating an environment for secure and reliable computing.

This benefit is quantified by estimating the improvement in virus attacks as 50%. Forrester assumes that security requires half of a full time equivalent, split between a senior and junior administrator. Estimating their fully burdened salary at \$100,000 and \$80,000, respectively, gives a savings of \$16,800 per year. Over three years, the present value of this savings is \$41,779.

Table 6: Improved Security Savings

Ref.		Calculation	Value
C7	Amount of time spent on virus attacks		.5
C8	Percent improvement		40%
C9	Senior administrator cost		\$100,000
C10	Percent of Senior time		20%
C11	Junior administrator cost		\$80,000
C12	Percent of Junior cost		80%
C13	Total annual savings	C7*C8* (C9*C10+C11*C12)	\$16,800

Source: Forrester Research, Inc.

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Total Benefits

The total benefits associated with the organization's use of the Sun Ray platform are illustrated in Table 7. The point at which the sample organization received positive payback on their investment was a year after the initial deployment.

Table 7: Total Benefits, Non Risk-Adjusted

Cash Flow Analysis (Original Estimates)						
Benefits	Initial	Year 1	Year 2	Year 3	Total	Present Value
Hardware Savings		\$72,000	\$72,000	\$72,000	\$216,000	\$179,053
IT Maintenance savings		\$400,000	\$600,000	\$800,000	\$1,800,000	\$1,460,556
Security Savings		\$16,800	\$16,800	\$16,800	\$50,400	\$41,779
Total		\$488,800	\$688,800	\$888,800	\$2,066,400	\$1,681,388

Source: Forrester Research, Inc.

Costs to Implement the Sun Ray Solution

Costs, or IT impact, are calculated as a change in costs primarily to IT as a result of the introduction of the technology to the given organization. Therefore, the purchase of the Sun Ray solution, as with another desktop investment, initially affects IT costs negatively, because the implementation requires incremental spending for both hardware, licensing, as well as labor costs related to the implementation. This is offset by future IT efficiencies resulting from the reduction in desktop administration.

Costs of implementing the Sun Ray solution included the following:

- Purchase of Sun Ray devices and Sun Ray software
- Maintenance
- Server
- Implementation Services
- Training

Sun Ray Costs

The sample organization had a variety of Sun Ray models, though none included peripherals. The average cost for the Sun Ray models at the sample organization was \$339; this included the \$299

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cost of the unit as well as a \$40 software cost. The total user population was 600 people, of which 60% had Sun Ray units. Therefore, the total cost of the Sun Ray clients was \$122,040[‡].

Table 8: Licensing Costs

Ref.		Calculation	Value
D1	Number of users		600
D2	Percent using Sun Ray		60%
D3	Total Sun Ray users	D1 * D2	360
D4	Cost of Sun Ray Device and Software		\$339
D5	Total Sun Ray cost	D3 * D4	\$122,040

Source: Forrester Research, Inc.

Maintenance Costs

The maintenance required for the Sun Rays is estimated at 1.5 full time equivalents (FTE). Using a fully burdened rate of \$100,000, this is \$150,000 per year, or a three year total of \$373,028 (present value).

Table 9: Maintenance Costs

Ref.		Calculation	Value
D6	Number of FTE		1.5
D7	Fully burdened rate		\$100,000
D8	Annual Maintenance cost		\$150,000

Source: Forrester Research, Inc.

Implementation Costs

The implementation period for the Sun Rays consisted of the six months prior to the actual installation and the year months following it. It was estimated that half a full time equivalent was required during this period in order to support users while they adjusted to the new platform. This came to a total of \$50,000 initially and \$25,000 over the first year. The present value of the total is \$72,727.

[‡] Newer Sun Ray technology is available at lower costs; the interviewed customer is using an older model.

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Table 10: Implementation Costs

Ref.		Calculation	Value
D9	Number of FTE		0.5
D10	Annual rate per person		\$100,000
D11	Years		1.5
D12	Total implementation cost	D9*D10*D11	\$75,000

Source: Forrester Research, Inc.

Server Costs

In order to fully take advantage of the Sun Ray benefits, the sample organization upgraded their servers; the interviewed company felt that this upgrade was important to utilize the benefits from the Sun ray platform. The company invested in two servers, each at a cost of \$10,000; the total cost was therefore \$20,000[§].

Table 11: Server Cost

Ref.		Calculation	Value
D13	Number of Sun Servers		2
D14	Cost of Sun Server		\$10,000
D15	Total Sun Server Cost	D13*D14	\$20,000

Source: Forrester Research, Inc.

Training Costs

The users underwent training on the new Sun Ray clients; it was estimated that each Sun Ray user had an average of three hours of training, at a cost of \$100 per hour. For the 360 users, that is a total cost of \$108,000.

[§] Sun servers are now available at lower costs.

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Table 12: Server Cost

Ref.		Calculation	Value
D16	Number of Sun Ray users		360
D17	Cost of Training (per hour)		\$100
D18	Hours of training per user		3
D19	Total Training cost	D16*D17*D18	\$108,000

Source: Forrester Research, Inc.

Total Costs

The total cost for the sample organization to implement the Sun platform is illustrated in Table 13.

Table 13: Total Costs, Non-risk-Adjusted

Costs	Cash Flow Analysis (Original Estimates)				Total	Present Value
	Initial	Year 1	Year 2	Year 3		
Sunray Cost	(122,040)				(122,040)	(122,040)
Maintenance Cost		(150,000)	(150,000)	(150,000)	(450,000)	(373,028)
Sun Server Cost	(20,000)				(20,000)	(20,000)
Implementation Cost	(50,000)	(25,000)			(75,000)	(72,727)
Training costs	(108,000)				(108,000)	(108,000)
Total	(\$300,040)	(\$175,000)	(\$150,000)	(\$150,000)	(\$775,040)	(\$695,795)

Source: Forrester Research, Inc.

Risk

Flexibility, as defined by TEI, represents the value of the options created by the technology platform. When one considers an investment, one can look at both the immediate benefits and the possibility of adapting that investment to meet unanticipated or potential needs. For example, if one buys a house, one will receive the benefit of living in it. If the house that was purchased can also be expanded to meet a changing family need, that extra option is of value to the original purchaser and makes the house more valuable than just the direct benefits imply. TEI attempts to put a value on these options, since they represent an additional asset that the organization has obtained as a result of implementing the basic technology platform.

These benefits could be turned into additional business benefits, depending on the future business needs of the organization. These potential benefits include taking advantage of the capability of the Java card (which can also be used as the employee badge for 1) Enhanced security via storage of biometric data on the card for strong authentication, 2) Placement of PKI certificates on the card for authentication, or 3) Placement of cash value on the card for commerce.

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The value of flexibility is clearly unique to each organization and the willingness of each organization to measure the value of flexibility varied considerably from organization to organization. For the purpose of this analysis, we have assumed that the composite organization has decided to use the Java card (smart card) for its most basic function, that is as an employee badge that provides building access and that can be used with Sun Ray client to enable “Hot Desking” (session mobility).

With any option, just as with the example of the option to expand a house, taking advantage of these options will require a second investment. We can estimate this cost and use it to value the options created, as with the value of the new house, or the additional business produced by the option.

Likewise, if the second investment is not made, due to business conditions not being in favor of the option's exercise, the option on flexibility will “expire” worthless. For the purpose of analysis here, two budget cycles, or two years, is often used as a good first step in looking at this expiration date for the option. The fact that this secondary project may or may not be funded in two budget cycles is reflected in the value of the option benefit.

Lastly, to value the option, we must consider the base value of money — which is reflected in the risk-free rate of return on capital — and the volatility or uncertainty about future conditions and needs. If an organization has clarity about future and there is little or no volatility, then a financial analysis of future spending becomes a net present value calculation. If there is uncertainty, then purchasing or obtaining options to hedge future business risks creates added value.

Flexibility Associated with Sun Ray Technology

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TEI Framework: Summary

Considering the representative numbers in the financial framework constructed above, the results of the "Costs," "Benefits," and "Risk" sections can be used to determine a return on investment, net present value, and payback period. Table 15 shows the consolidation of these numbers for the sample organization.

Table 15: Total Costs And Benefits, Non-Risk-Adjusted

Cash Flow Analysis (Non-Risk-Adjusted)						
Project Cash Flow	Initial	Year 1	Year 2	Year 3	Total	Present Value
Total Costs	(\$300,040)	(\$175,000)	(\$150,000)	(\$150,000)	(\$775,040)	(\$695,795)
Total Benefits		\$488,800	\$688,800	\$888,800	\$2,066,400	\$1,681,388
Net Savings	(\$300,040)	\$313,800	\$538,800	\$738,800	\$1,291,360	\$985,593
ROI						142%
Payback Period						1.0 years

Source: Forrester Research, Inc.

Table 16 below shows the risk-adjusted values, applying the risk-adjustment method indicated in the "Risks" section to the numbers in Tables 15.

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Table 16: Total Costs And Benefits, Risk-Adjusted

Cash Flow Analysis (Risk-Adjusted)						
Project Cash Flow	Initial	Year 1	Year 2	Year 3	Total	Present Value
Total Costs	(\$312,040)	(\$208,333)	(\$183,333)	(\$183,333)	(\$887,040)	(\$790,690)
Total Benefits		\$484,800	\$684,800	\$884,800	\$2,054,400	\$1,671,441
Net Savings	(\$312,040)	\$276,467	\$501,467	\$701,467	\$1,167,360	\$880,751
ROI						111%
Payback Period						1.0 years

Source: Forrester Research, Inc.

It is important to note that values used throughout the TEI framework are based on in-depth interviews with a sample organization. Forrester makes no assumptions as to the potential return that other organizations will receive within their own environment. Forrester strongly advises that readers use their own estimates within the framework provided in this study to determine the expected financial impact of purchasing the Sun platform.

Study Conclusions

Based on information collected in interviews with a current Sun customer, Forrester found that organizations that implement the Sun Ray technology can realize significant benefits in the form of savings from decreased hardware expense, improved administration, and improved security.

The in-depth interviews uncovered that using Sun Ray technology can drive efficiencies both inside and outside of the IT organization to realize the following benefits:

- Reduction in hardware costs.
- Improved administration and operational efficiencies.
- Improved protection from security breaches

The Sun platform was installed in less than three months and creates an environment which requires significantly less expensive hardware and internal maintenance. Overall, the Sun solution provided a significant return on investment for the sample company.

The financial analysis provided in this study illustrates the process for an organization to evaluate the value proposition of Sun Ray clients in its environment. Based on information collected in in-depth interviews with a Sun customer, Forrester calculated a three-year risk-adjusted ROI for the sample organization of 111%, with a payback after 1.1 years. All final estimates are risk adjusted to incorporate potential uncertainty in the calculation of costs and benefits. The calculation for ROI was based on the specific incremental costs and benefits from implementing the Sun Ray solution.

Based on these findings, companies looking to use the Sun Ray solution can see the potential of significant IT and organizational benefits. Using the TEI framework, many companies may find the potential for a compelling business case to make such an investment.

Appendix A: Total Economic Impact™ Overview

Total Economic Impact™ is a methodology developed by Forrester Research, Inc. that enhances a company's technology decision-making processes and assists vendors in communicating the value proposition of their products and services to clients. The TEI™ methodology helps companies demonstrate, justify, and realize the tangible value of IT initiatives to both senior management and other key business stakeholders.

The TEI methodology consists of four components to evaluate investment value: benefits, costs, risks, and flexibility. For the purpose of this analysis, the impact of flexibility was not quantified.

Benefits

Benefits represent the value delivered to the user organization — IT and/or business units — by the proposed product or project. Often product or project justification exercises focus just on IT cost and cost reduction, leaving little room to analyze the effect of the technology on the entire organization. The TEI methodology and the resulting financial model place equal weight on the measure of benefits and the measure of costs, allowing for a full examination of the effect of the technology on the entire organization. Calculation of benefit estimates involves a clear dialogue with the user organization to understand the specific value that is created. In addition, Forrester also requires that there be a clear line of accountability established between the measurement and justification of benefit estimates after the project has been completed. This ensures that benefit estimates tie back directly to the bottom line.

Costs

Costs represent the investment necessary to capture the value, or benefits, of the proposed project. IT or the business units may incur costs in the forms of fully burdened labor, subcontractors, or materials. Costs consider all the investments and expenses necessary to deliver the proposed value. In addition, the cost category within TEI captures any incremental costs over the existing environment for ongoing costs associated with the solution. All costs must be tied to the benefits that are created.

Risk

Risk measures the uncertainty of benefit and cost estimates contained within the investment. Uncertainty is measured in two ways: the likelihood that the cost and benefit estimates will meet the original projections and the likelihood that the estimates will be measured and tracked over time. TEI applies a probability density function known as “triangular distribution” to the values entered. At a minimum, three values are calculated to estimate the underlying range around each cost and benefit.

Flexibility

Within the TEI methodology, direct benefits represent one part of the investment value. While direct benefits can typically be the primary way to justify a project, Forrester believes that organizations should be able to measure the strategic value of an investment. Flexibility represents the value that can be obtained for some future additional investment building on top of the initial investment already made. For instance, an investment in an enterprisewide upgrade of an office productivity suite can potentially increase standardization (to increase efficiency) and reduce licensing costs. However, an embedded collaboration feature may translate to greater worker productivity if activated. The collaboration can only be used with additional investment in training at some future point in time. However, having the ability to capture that benefit has a present value that can be estimated. The flexibility component of TEI captures that value.

Appendix B: Glossary

Discount rate: The interest rate used in cash flow analysis to take into account the time value of money. Although the Federal Reserve Bank sets a discount rate, companies often set a discount rate based on their business and investment environment. Forrester assumes a yearly discount rate of 10% for this analysis. Organizations typically use discount rates between 8% and 16% based on their current environment. Readers are urged to consult their organization to determine the most appropriate discount rate to use in their own environment.

Net present value (NPV): The present or current value of (discounted) future net cash flows given an interest rate (the discount rate). A positive project NPV normally indicates that the investment should be made, unless other projects have higher NPVs.

Present value (PV): The present or current value of (discounted) cost and benefit estimates given an interest rate (the discount rate). The PV of costs and benefits feed into the total net present value of cash flows.

Payback period: The breakeven point for an investment. The point in time at which net benefits (benefits minus costs) equal initial investment or cost.

Return on investment (ROI): A measure of a project expected return in percentage terms. ROI is calculated by dividing net benefits (benefits minus costs) by costs.

A Note On Cash Flow Tables

The following is a note on the cash flow tables used in this study (see the Example Table below). The initial investment column contains costs incurred at “time 0” or at the beginning of Year 1. Those costs are not discounted. All other cash flows in years one through three are discounted using the discount rate shown in Table 4 at the end of the year. Present value (PV) calculations are calculated for each total cost and benefit estimate. Net present value (NPV) calculations are not calculated until the summary tables and are the sum of the initial investment and the discounted cash flows in each year.

Example Table

Ref.	Category	Calculation	Initial cost	Year 1	Year 2	Year 3	Total

Source: Forrester Research, Inc.

Appendix C: Adjusting For Investment Risk (Example)

This example provides a high-level illustration of the measurement of investment risk to a single benefit estimate. The table below provides a high-level overview of the following steps.

Benefit	Step 1			Step 2		Step 3	
	Original estimate	High	Low	Bias adjustment		Risk adjusted	
				%	Value	%	Value
Benefit 1	\$2,000	\$2,400	400	80%	\$1600	87%	\$1395

Step 1: Calculate original cost and benefit estimates

Suppose that an organization is trying to estimate the different types of benefits that might arise from a given technology investment. One potential expected benefit is savings per employee from the use of the technology. A sample benefit calculation is as follows:

Ref.	Metric	Calculation	Estimate
A1	Number of employees		200
A2	Savings per employee		\$10
A3	Total yearly estimated savings	A1 * A2	\$2,000

The \$2,000 represents the organization's original estimate of the yearly impact of the technology investment.

Step 2: Calculate the impact of bias for cost and benefit estimates

In Step 2, we account for the impact of bias in our original cost and benefit estimates. To measure the impact of bias, we need to calculate the range of possible outcomes of our original estimate by estimating possible high/low variables around our original estimates.

Ref.	Metric	Calculation	Estimate	Low	High
A1	Number of employees per year		200		
A2	Savings per employee		\$10		
A3	Total yearly estimated savings	A1*A2	\$2,000	\$400	\$2,400
B1	Bias adjusted estimate	$(\$2,000 + \$400 + \$2,400) / 3$	\$1,600		

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In the case of our example, we have calculated our original estimate (\$2,000), our low estimate (\$400), and our high estimate (\$2,400). The unbiased estimate is calculated as the mean of the high and low estimates: $[(\$2,000 + \$1,200 + \$2,400)/3 = \$1,600]$. The revised estimate is now \$1,600. Reference A4 in the above table presents the revised estimate.

Step 3: Calculate the impact of variance on cost and benefit estimates

Once we have determined the impact of bias in our original estimates, the next step is to calculate the impact of variance. Variance measures the possible spread within our estimates. In the case of our example, the variance is based upon the low estimate (\$400), the high estimate (\$2,400), and the revised estimate (\$1,600). A wider spread would create higher uncertainty and, as a result, greater risk.

To calculate the impact of variance, we need to use the following calculations:

$$\frac{[(Lx)^2 + (x2)^2 + (Hx)^2] - (Lx) * (x2) - (Lx) * (Hx) - (x2) * (x2) * (Hx)}{18} = Var(x2)$$

Where		
Lx	Low estimate	\$400
X2	Revised (biased adjusted) estimate	\$1,600
Hx	High estimate	\$2,400

$$\frac{[(400)^2 + (1600)^2 + (2400)^2] - (400) * (1600) - (400) * (2400) - (1600) * (2400)}{18} = 168889$$

The standard deviation represents the square root of the variance:

$$\hat{\sigma}(x2) = \sqrt{Var(x2)}$$

$$\hat{\sigma}(x2) = \sqrt{168889} = 411$$

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The final calculation in our analysis is to create a measure for the impact of risk on the cost or benefit estimate. To do this, we use the following equation:

Risk impact: [(standard deviation of estimate)/ (unbiased estimate)] * 1/2

$$\text{Risk Impact} = 1 - \left[\frac{[\partial(x^2)]}{x^2} \right] * \frac{1}{2}$$

$$\text{Risk Impact} = 1 - \left[\frac{411}{1600} \right] * \frac{1}{2} = 1 - 12.8\% = 87.2\%$$

The logic behind the equation for risk impact is as follows:

- We first divide the standard deviation into the unbiased estimate to get an estimate of the magnitude of the mean of the distribution to the possible spread of the distribution. This ratio allows us to compare the impact of risk multiple cost and benefit estimates by reducing it to a percentage.
- We next multiply the original ratio by 1/2 to measure only the likelihood of the potential downside of the estimate. Multiplying by 1/2 allows us to look at the part of the distribution where the likelihood that the costs will be higher than estimated (the right side of the distribution) or benefits that are lower than originally estimated (the left side of a normal distribution).

The table below illustrates the progression of the original benefit estimate to the risk-adjusted benefit estimate, accounting for the impact of variance.

Impact of bias and risk	
Original estimate	\$2,000
Revised estimate	\$1,600
Risk-adjusted estimate	\$1,395