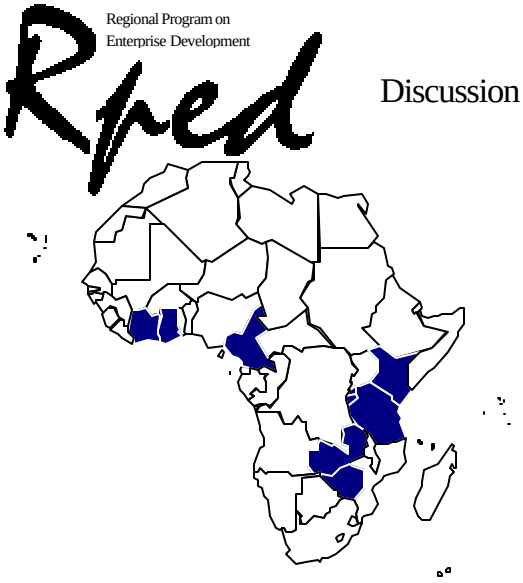

Discussion Papers

A Microeconometric Evaluation of the Mauritius Technology Diffusion Scheme (TDS)

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Tyler Biggs

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1. Introduction

This evaluation of the Technology Diffusion Scheme in Mauritius was carried out as part of a larger review of "matching grant" schemes supporting technological development in African firms. The matching grant scheme has become a popular new tool for private sector development in Africa. In the past, efforts to improve enterprise technical capabilities were directed at putting aid resources into government institutions that supplied technical services in the hope that this would provide what was analyzed as being 'missing". The matching grant mechanism takes a different approach, putting resources into the hands of purchasers of services, on a cost-sharing basis, allowing them to choose what technology transfer services make best sense for them, and allowing them to select their own service providers. The advertised success of such efforts in other parts of the world – namely Asia, where they were used to support export development – has encouraged their use in Africa.

What is not clear yet is how such schemes will work in Africa. Only two schemes have been completed to date – the Kenya Export Development Scheme and the Technology Diffusion Scheme in Mauritius. The others – currently operating in ten countries – are in various stages of maturity. None to our knowledge have been properly evaluated. Our review is a first attempt to comprehensively assess the matching grant tool across Africa in terms of (a) the rationales for such schemes, (b) the degree to which they have been implemented to address these rationales, and (c) the methods to evaluate their success.

This evaluation of the Mauritius Technology Diffusion Scheme was undertaken to serve as a "benchmark" for assessing matching grant schemes in other countries. It is the first microeconomic study evaluating the effects of a matching grant scheme in a

* Thanks are due to Gerald Tyler, who provided assistance in data collection and analysis, particularly for the qualitative assessment of benefits in Table 8 and scheme management issues. Also to John Nasir and Lan Zhao, who provided research assistance for field data collection and the quantitative analysis of benefits. Anthony Calamitsis provided assistance with the data in Table 1.

developing country context. Mauritius provides us with an almost ideal environment for such an evaluation. Mauritius, unlike most countries in sub Saharan Africa, has relatively good official data on manufacturing firms – particularly EPZ enterprises which were the intended principal beneficiaries of the Technology Diffusion Scheme. It is also a country where macroeconomic policy is conducive to exports and growth, and where firms are currently engaged in a competitive struggle to acquire new technologies and move up to higher-end exports, in the face of rising real wages resulting from their past export successes. Furthermore, the Technology Diffusion Scheme is one of the few matching grant efforts in Africa which has completed its disbursement of funds, and therefore has records on firms with recent experience of matching grant assistance able to provide good information on the impact of these grants.

Our evaluation is a bit more comprehensive and pedagogical than it might be because it is written to provide both a conceptual and methodological guide to those involved in assessing the impact of matching grants, as well as to provide a detailed evaluation of the Technology Diffusion Scheme's payoff to the Mauritian economy. The report is structured to answer a series of questions of interest to evaluators. Section 2 asks: What were the central rationales for the Technology Diffusion Scheme as set out by the government of Mauritius and the Staff Appraisal Report of the Bank? Section 3 looks at the question: Was the Technology Diffusion Scheme implemented successfully to address these rationales? Section 4 asks: Did the Technology Diffusion Scheme create incentives to expand economic benefits beyond those to directly assisted firms to stimulate the market for business support services? Lastly, Section 5 addresses the central question: Did the Technology Diffusion Scheme generate positive *economic* benefits for the Mauritius economy?

In brief, the evaluation finds that there were sound economic rationales for government involvement in a matching grant scheme supporting technology transfer at the time the Technology Diffusion Scheme began. For the most part, the Technology Diffusion Scheme was set up and administered well – grant proposals were processed efficiently and payments were made to assisted firms in a timely fashion. There were problems in design and implementation of the scheme, however, which seriously reduced the *economic* benefits that might have been achieved. As the evaluation shows, the

central difficulties revolved around problems of promoting "additionality" – funding activities the private sector would have financed on its own – and "selectivity" – failure to establish a clear distinction between the *private* benefits to firms and the broader *economic* benefits to society in extending grant support. Together these two factors establish the necessary and sufficient conditions for any successful public subsidy program to assist private enterprises, and they were not adequately emphasized in the design and implementation of the Technology Diffusion Scheme.

2. What was the Rationale for the Technology Diffusion Scheme (TDS)?

In the 1970s and 80s, Mauritius built up an export-oriented manufacturing sector which derived its competitive advantage from cheap labor, friendly foreign investment policies, and a core of dynamic local entrepreneurs. This early phase of manufactured export growth involved relatively simple skills and technologies.

By the late 1980s, export success began to create the conditions for its own demise. Real wages rose at a rate of more than 8 percent per year in the late 1980s and early 1990s, while growth in labor productivity lagged behind at 5 percent per annum. The resulting increase in unit labor costs began to seriously erode national competitiveness, particularly in the price sensitive segments of the textile industry, where the lion's share of Mauritian exports were concentrated. Clearly it was time for Mauritian exporters to think about moving up to higher value products and to begin diversifying into more technologically sophisticated export industries where competition would be less dependent on price. To be successful in this transition, however, firms would have to substantially upgrade their technological capabilities to compete more on quality and response time.

Taking its cue from policies implemented in the Asian NICs, the Government of Mauritius, in collaboration with the private sector, initiated a new technology policy called the "Technology Strategy for Competitiveness." This policy involved two elements: a review of key government policies and regulations to ensure that they supported the private sector's efforts to achieve higher levels of technological capability and competitiveness and the initiation of direct government support programs to assist the

private sector in technology transfer and diffusion. The Technology Diffusion Scheme (TDS) was one of the initiatives designed to address the second element of the strategy.

Government had long influenced technology transfer, and private manufacturing investment more generally, through its macroeconomic, tax, trade, and regulatory policies. In addition, public investments in education and infrastructure had further conditioned the inflow of advanced foreign commercial technologies and their adoption. To assist in facilitating the country's planned transition to higher-value exports, the government decided it needed to do more. In order to increase the amount and quality of technology transfer by the private sector, government elected to become more actively involved in funding these efforts. Justifications for the government's more direct role in technology transfer, according to the Bank's Staff Appraisal Report for TDS, were based on perceived market imperfections which were purported to be causing private firms to under-invest in these activities.

First, it was generally accepted that a good portion of the benefit of technology transfer cannot be captured or "appropriated" by the firm engaged in the initial transfer activity. Often the benefits of one firm's technology transfer investment "spill over" to others that, without investing much in the know-how, nevertheless learn about its results. Because of such "spillovers," the economic benefits of technology transfer are often greater than the returns to any individual firm that undertakes them. As a result, the Mauritian private sector was expected to invest too little in technology transfer relative to what is economically optimal.

Second, it was argued that the resource costs, transaction costs, and uncertainties involved in the technology transfer process in Mauritius often constrain the acquisition of critical new technologies. Transfer of foreign technology entails a number of tasks, and some of them are, characteristically, very expensive, involve information assymetries and contract enforcement problems, and engender a good deal of uncertainty. Many of these tasks require the physical presence of experienced foreign users, others require expert trainers and engineers to upgrade the work force and adapt the technology to local circumstances. Still others require facilitating institutions to mediate and enforce contracts, and reduce the costs and time involved in information gathering. In Mauritius, where the traditional technology transfer mechanisms are still missing or weak (e.g.,

where expert local consulting services and/or training services are unavailable or inadequate and where firms are far from the markets they serve), the private marginal cost of technology transfer can be higher than in competing countries, and, in some cases higher than the marginal economic cost of transfer. Financial market imperfections can complicate this problem further. It is often difficult to finance the "softer" elements of technology transfer, like expert consultants and training. While banks will finance collateralizable equipment purchases, they will often not finance foreign technical consultants, training experts, and local adaptation of the technology, which are crucial to its efficient operation.

Dealing with these high costs and uncertainties of transfer, as well as any impediments which may be erected by developed country patent holders, can reduce the expected returns to technology transfer investments enough to make them unattractive to private firms. Financial market constraints may even constrain technology transfer in cases where investments have high expected returns. Such factors can impede private sector investment in technology transfer relative to what is economically optimal.

Based on such rationales, the government, with assistance from the Bank, established the Technology Diffusion Scheme with the specific objectives of increasing the amount of technology transfer to exporting firms, and promoting greater technology diffusion within the economy via "spillovers" in the form of "strong demonstration effects" which additional technology transfer could make possible. Success of the scheme was to be measured by four factors: (a) the amount of technology transfer and diffusion carried out by scheme-assisted private manufacturing firms; (b) the degree to which matching grant assistance could create incentives for establishment of a local market for technology transfer support services (e.g., expert consulting services); and (c) the impact of the scheme on firm performance (e.g., sales, exports).

2.1 Soundness of the Rationales for Government Intervention in Mauritius

The theoretical literature on market failures associated with technology transfer is substantial. There is also a steadily growing empirical literature verifying the importance of spillovers (externalities) in technology transfer activities. Thus, it would appear that a

clear economic justification exists in theory for public support to encourage more investment in technology transfer, by way of reducing market imperfections, by stimulating the development and use of technology support services, and by promoting complementarities among technology investments via greater government coordination.

Moreover, at the time TDS was initiated, the economic environment in Mauritius was favorable for such support. Macroeconomic conditions and trade policies were generally supportive of manufactured exports. And Mauritian firms, facing considerable competitive pressure to upgrade their technical capabilities, were primed for the acquisition of new production technologies. As the Staff Appraisal Report for TDS argued, based on the data in Table 1 below:

> "Mauritian producers are becoming increasingly less competitive in world markets (i.e., the EPZ competitive index had declined 50 percent between 1983 and 1993)…this growing competitiveness problem is caused in large part by the failure of productivity growth to keep up with rising labor costs and with the changing competitive conditions in global markets. Hence there are substantial indications that private sector demand is currently high for a government technology support scheme."

Table 1
Competitiveness Indicators for the EPZ (1983-1998)
(Base Year 1982=100)

												Technology Diffusion Scheme				
	1983	**1984**	**1985**	**1986**	**1987**	**1988**	**1989**	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997***	**1998****
No. of Enterprises (as of December)	146	195	287	408	531	591	563	568	586	558	536	494	481	481	480	485
Employment (as of December)	25,526	37,472	53,951	74,015	87,905	89,080	88,658	89,906	90,861	86,937	85,621	82,176	80,466	79,793	83,391	87,057
Value added (Rs M)	548	865	1,333	1,860	2,585	3,125	3,400	3,975	4,406	5,011	5,702	6,373	7,096	8,163	9,172	10,260
Wages (Rs M)	263	407	661	975	1,274	1,559	1,741	2,075	2,353	3,111	3,304	3,634	3,940	4,200	n.a.	n.a.
Exports (Rs M)	1,307	2,151	3,283	4,951	6,567	8,176	9,057	11,474	12,136	13,081	15,821	16,533	18,267	21,000	23,049	26,074
Value added to Exports (%)	41.9	40.2	40.6	37.6	39.4	38.2	38.1	34.6	36.3	38.3	36.0	38.5	38.8	39.0	39.8	39.3
Wages to Value added (%)	48.0	47.1	49.6	52.4	49.3	49.9	51.2	52.2	53.4	62.0	57.9	56.8	55.3	55.0	n.a.	n.a.
Wages to Exports (%)	20.1	18.9	20.1	19.7	19.4	19.1	19.5	18.1	19.4	23.8	20.9	22.0	21.6	20.0	n.a.	n.a.
Productivity Index	100	98	85	85	89	96	102	110	115	124	136	145	155	159	163	n.a.
Labor Cost Index	115	133	167	182	200	222	236	262	294	332	333	351	361	368	370	n.a.
Competitiveness Index	87	74	51	47	45	43	43	42	39	37	41	41	43	43	44	n.a.
Investment (Rs M)	74	210	340	560	655	870	900	690	648	560	900	900	815	930	1245	n.a.
- Machinery (Rs M)	[64]	[165]	[260]	[450]	[530]	[730]	[840]	[640]	[610]	[540]	[875]	[880]	[805]	[915]	[1200]	n.a.
Investment (US$ M)	6	13	24	43	54	63	60	48	44	33	48	50	46	52	57	n.a.
Exchange Rate (Rs per US$)***	12.723	15.603	14.310	13.137	12.175	13.834	14.996	14.322	14.794	16.998	18.656	17.863	17.664	17.972	21.930	22.852

Productivity Index (base 1982): variation in value added per worker
Labor Cost Index (base 1982): variation in labor costs
Competitiveness Index: Productivity Index/ Labor Cost Index (reciprocal of unit labor cost index)
n.a.: not available

* Revised
** Estimate
*** End of period rate

Sources: Bank of Mauritius Annual Report, Year ended 30 June 1998; Central Statistical Office Digest of Industrial Statistics 1996; Export Processing Zone Development Authority Annual Report 1997/98; and International Financial Statistics, July 1998.

3. Was the Technology Diffusion Scheme (TDS) Implemented Successfully?

While it appears there were sound economic rationales for TDS, an evaluation of a government intervention such as this should involve two issues: *the soundness of the rationales themselves and the ability of the government to implement a scheme to address these rationales*. For there are often good theoretical grounds for government intervention, but there are reasons to believe that government may be limited in its ability to implement these interventions in a manner likely to successfully address the economic rationales underpinning them. In the case of a technology subsidy scheme like TDS, successful government implementation will crucially depend upon its ability to pick "good" technology transfer projects, a problem to which we now turn.[1]

3.1 The Problem of Selecting the "Right" Projects in Publicly Funded Technology Transfer Schemes

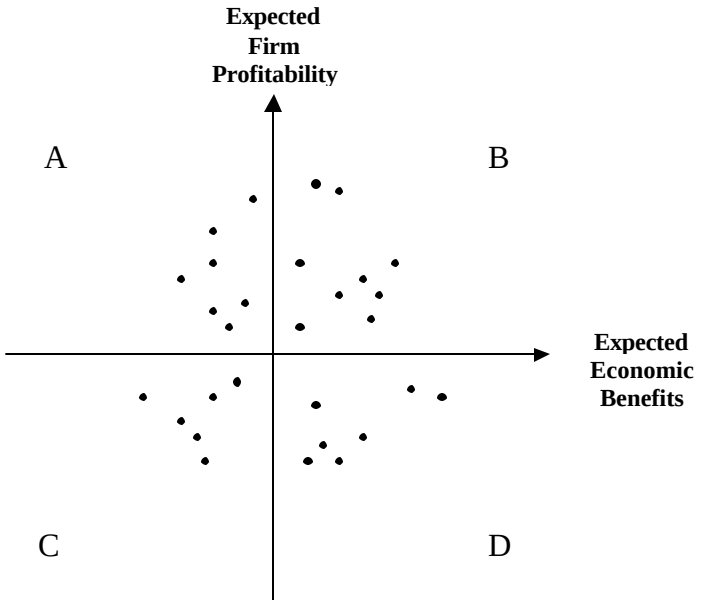
In the end, government's implementation problem boils down to its ability to select projects that give the "biggest return for the rupee" in terms of the economic rationales for the scheme. To achieve this goal, scheme managers must succeed at two tasks: *selecting projects with large economic (social) returns to the country and funding* ***only*** *those projects that would not otherwise find private funding*[2]. The first task involves searching for the maximum economic returns for the government rupee when making project grants. The second task relates to the fact that there is no need to subsidize (with taxpayer funds) technology transfer investments that the private sector would fund on its own. Public funding should not "crowd out" private funding. Scheme managers must strive to achieve "additionality," in the sense that public subsidies should provide incentives for firms to increase their technology transfer investments beyond what they would have funded on their own. Fostering additionality might also include inducing

[1] A "project" in this context refers to a private firm's technology transfer investment project.
[2] While these objectives of publicly funded technology subsidy schemes were not highlighted prominently in the design of TDS, they were noted in the scheme's Staff Appraisal Report — Paragraph 2.34 pointed out the importance of public support "not crowding out private sector initiative and endeavor," and paragraph 3.8 and others called attention to the importance of promoting large economic returns in the form of spillovers or "strong demonstration effects."

firms to make investments *sooner* than they might have, and/or inducing firms to make "*better*," or higher quality investments.

Figure 1 can be used to illustrate these necessary and sufficient conditions for successful project selection.[3] The horizontal dimension (X-axis) is a measure of how "good" technology transfer projects are in economic (social) terms. Economic benefits include profits to investing firms plus profits in the form of "spillovers" (knowledge or pecuniary spillovers) to other firms and to consumers who might benefit from "demonstration effects," lower prices, or higher product quality stemming from increased investment in technology transfer. "Good" projects generate larger economic benefits and are farther to the right along the horizontal axis. The vertical dimension (Y-axis) measures expected firm profitability, or the degree to which a firm thinks it can increase its profits by the technology transfer project. Projects with high expected firm profitability increase as we move up the vertical dimension.

Figure 1



Points representing technology transfer projects in quadrant (B) are investments where firms expect positive profits and where positive economic benefits are generated in

[3] The argument in this section is adapted from the discussion in Yeager and Schmitz (1997). *The Advanced Technology Program: A Case Study in Federal Technology Policy*. Washington, DC: AEI Press.

the form of knowledge and pecuniary spillovers to others. For the most part, firms have sufficient incentives to fund these technology transfer investments on their own. Therefore, absent financial market imperfections, which might constrain the firm's ability to fund these technology transfer investments, projects in quadrant (B) can be labeled as "good" projects that would be done anyway. If the government funds projects that fall in this quadrant, particularly the ones with high expected firm profitability up towards the top of the vertical axis, it is simply displacing ("crowding out") technology transfer investments that the private sector would have pursued on its own.

Projects in quadrant (A) represent those technology transfer projects where firms make a profit, but at a net cost to society. Projects in this quadrant can be labeled as "bad" projects that might be done anyway. An example of such investments would be technology transfer to improve techniques in cigarette manufacturing or polluting technologies which damage the environment. Such projects would increase private profits, but, since government and commercial entities have to invest in response to these efforts, society may be worse off as a result.

Projects represented in quadrant (C) are not profitable for firms or for society. These can be labeled as "bad" projects not likely to be funded privately.

Finally, projects represented by points in quadrant (D), in most cases, can be labeled unequivocally as the "target" technology transfer projects for the government scheme. Projects in this quadrant have positive economic benefits to society, but are not sufficiently profitable to attract private investment. To the extent that the matching grant scheme is able to identify and provide funding to these projects, it is likely to address some of the rationales cited as the basis for government intervention.

Two central reasons why projects in quadrant (D) may *not* be sufficiently profitable to private investors are the high costs and uncertainties of technology transfer, and the inability of investors to capture the full benefits from their technology transfer activities. In newly industrializing countries, a number of factors influence the resource and transaction costs of technology transfer:[4] (a) the number of previous experiences with technology transfer; (b) the sophistication of the technology being transferred; (c) the

[4] Teece, David J. "Technology Transfer by Multinational Firms: The Resource Cost of Transferring Technological Know-how." Economic Journal 87(June 1977).

number of local firms possessing a technology similar to the technology being transferred; (d) the number of years the firm has been involved in manufacturing; (e) whether or not the transferring firm is an affiliate of the owner of the technology; and (f) the level of development of the country in which the transferring firm resides (this is a proxy for the level of infrastructure development, the skill level of workers, and the strength of existing technology transfer mechanisms, as we noted earlier). The Government of Mauritius, as we noted earlier, made a case that, on average, firms face higher uncertainties and higher technology transfer costs in Mauritius because they are relatively inexperienced in technology transfer compared with rival firms in international markets. In addition, Mauritian firms often face higher information and resource costs because the technology transfer mechanisms, which normally operate to facilitate and mediate technical learning in industrialized countries, are still relatively underdeveloped. Considering such weaknesses in the technology transfer process, and the fact that technology transfer involves spillovers which cannot be captured by investors, an offsetting government subsidy is warranted to reduce the impact of market failure and bring technology transfer up to more economically optimum levels.

3.2 The Problem of Selecting the "Right" Firms

Just as funding the "right" projects is important for getting the "biggest return for the rupee," so also is funding the "right" firms. One has to consider the fact that there can be heterogeneous responses to government subsidy support. That is, there can be differences across firms in the marginal economic benefits of the subsidies for any given technology transfer investment. Performance outcomes across firms, holding other things constant, will generally depend on the firm's "capability." At a minimum, firms must have a modicum of planning, technical, and financial capability to use the public subsidies productively. For example, lacking technical capability, a firm may be unable to benefit from the skills of a foreign expert subsidized by a cost-sharing grant. Or, lacking financial capability, a firm might be constrained in making complementary investments necessary to reap maximum benefits from the technology transfer investment it has made with public support.

Heterogeneous responses to government funding requires that the selection of companies receiving subsidies has to be "performance-based" — subsidies must go to "performers" who can achieve maximum outcomes in terms of the objectives of the cost-sharing scheme. In Mauritius, this is not as big a problem as it can be elsewhere in Africa. Over the last 25 years many Mauritian firms have developed world-class capabilities in export markets and can generally make good use of the subsidies provided. However, there can be pressure in government subsidy schemes to try to spread the subsidies as broadly as possible. For example, a reading of the minutes of the TDS Steering Committee meetings indicates that, over the four years TDS was implemented, there was a continuing pressure applied by various interest groups to broaden the beneficiary group to include activities other than manufacturing and to include more smaller enterprises.

3.3 Was the Technology Diffusion Scheme Designed and Managed to Select the "Right" Projects?

Background and Basic Design Characteristics of the Technology Diffusion Scheme. During the four years life of TDS, 224 technology transfer projects were funded in 154 private firms. Of these 224 projects, 13 were "group" projects involving multiple enterprises (38 enterprises benefited from the scheme in this way). Group projects were included in the scheme's design to allow small firms to benefit from technology subsidies. Approximately one-third of the grants awarded by TDS went to small enterprises with fewer than 50 employees.

$2.7 million in government funds were committed to TDS. By the end date of the scheme in June 1999, $2.16 million had been allocated to various projects and $0.493 million to the cost of the scheme's management (about 22 percent of total grant funds awarded). The average size of grant awarded to firms was $9,600. The total amount of resources devoted to technology transfer projects funded under TDS is at least twice the amount allocated under the scheme, as recipients of grants were required to fund 50

percent of the project costs themselves.[5] This 50/50 funding requirement was included in the scheme's design elicit maximum commitment on the part of recipients, which is best achieved when they also have a vested interest in the project's outcome.

Firm proposals for funding were vetted by a private management contractor hired by the government to administer the TDS and manage the grant-making process. The management contractor worked in the Ministry of Industry and Industrial Technology under guidance of a Supervision Committee whose members included representatives of both the public and private sectors. TDS grants were evaluated on the basis of eligibility criteria, which specified the target group (manufacturing firms and services supporting manufacturing) and technology transfer project types eligible for subsidies under TDS. This approach was designed to ensure that TDS awarded grants based on the rationales of the scheme rather than on political influence.

Restrictions were also placed on the grant-making process. Qualifying firms had to have at least 51 percent of their equity in private hands. Maximum grant support over the life of TDS was limited to $100,000 for any individual firm. Firms were also limited to one grant per qualifying activity. If a firm had already received a grant for one of the five project types allowed under the scheme, it was restricted in applying for a second grant in the same area even when the firm had not yet reached its $100,000 total support limit.

TDS designers and managers made an effort to evaluate projects once grants were made. Recipients were required to provide specified "deliverables" for each project "to allow TDS managers to verify project activities" (for example, in the case of a quality system project, like ISO 9000, a grant recipient was required to supply TDS managers with the procedures and quality manuals drawn up by the consultant). Project-specific and firm-specific "monitorables" were also required. Grant recipients had to provide TDS managers with a specific, measurable expected output indicator for each qualifying project (for example, a productivity improvement project in a garments factory might specify that the project-specific monitorable is to reduce costs or time in a particular manufacturing operation — like cloth cutting or garment assembly — by 10 percent). In addition, assisted firms were also required to provide information on their sales and

[5] In most cases, we found that TDS' contribution to the average firm's technology transfer project was, in fact, quite small.

exports prior to receiving the TDS grant and again at indicated intervals over the year following the grant. Finally, the Bank required that TDS be evaluated at the midpoint of the scheme and at its end.[6]

Management and Project Selection. Firms have little incentive to propose projects to scheme managers that meet the requirements for public funding — low private profitability and large economic benefits to society. Rather, it should be expected that firms will concentrate on the private profitability of technology transfer investments and will create internal selection mechanisms to sort out their investments using this criteria. Conducting feasibility studies based on the expected private profitability of investments is difficult enough — firms have no incentive to think about the economic (social) benefits that might spill over to the wider society on account of their projects.

Consequently, it is the job of the designers and managers of publicly-funded schemes like TDS to develop and apply eligibility criteria that make it possible to elicit the "right" projects from firms and then to select from among these projects the ones with the highest potential economic benefits to society. How well did TDS designers and managers do this job?

Promoting "Additionality…"

The design features of the TDS scheme and the procedural manuals[7] show significant efforts to avoid problems in administration and project selection. A private management contractor was hired to run the scheme, with oversight provided by a joint government-private supervisory committee, to try and avoid potential problems which can arise when government selects projects (political influence, lack of technical expertise, and fear and uncertainty in public-private interactions). Strict eligibility requirements were specified for the types of technology projects and sectors allowed to participate in the scheme. Application procedures and documentation requirements were instituted to screen projects and recipients. A funding limit of 50 percent of a proposed

[6] At the midpoint, the Bank hired a consulting firm to evaluate the scheme (see "An Evaluation of the Mauritius Technology Scheme," New World Ventures, 1997). The final evaluation was done by the management contractor hired to run the scheme (see "Mauritius Technology Diffusion Scheme: Final Report," Segal, Quince and Wickstead, Ltd., 1998).

[7] Manual of Policies and Procedures and How to Apply for a TDS Grant. Mauritius Technology Diffusion Scheme, 1995.

project was stipulated to ensure recipient commitment. Finally, monitoring and evaluation, by way of project-specific and firm-specific monitorables, were instituted to assess the impact of selected projects. All of these efforts should be applauded.

Notwithstanding such efforts to avoid project selection problems, however, one finds no requirement that the "additionality criterion" be met — a critical necessary condition for successful implementation. There were no explicit criteria established by the scheme's designers and managers to ensure that the scheme promoted additional technology transfer rather then simply subsidizing projects that would have found private funding on their own. A maxim of the scheme, as set out in the Manual of Policies and Procedures, was that public support should be "demand-driven" — firms should decide what they need and submit proposals to the scheme. Proposals for funding should be selected based on whether or not the project could satisfy certain eligibility requirements. The ***project*** was eligible for funding if it: (a) fit well into the firm's business plan; (b) met TDS' eligibility criteria for the five types of technology transfer projects it would fund; and (c) could be funded under the financing limits of the scheme. The ***firm*** was eligible if it: (a) was a member of the target group; (b) submitted to an interview with TDS managers; (c) prepared an acceptable business plan; and (d) provided evidence of financial solvency. Each of these eligibility requirements operated to circumscribe the selection processes in terms of target group and project type. But, there was no explicit requirement in the formal TDS procedural documentation that managers should ensure that public funding be used to promote "additionality." That is, no specific guidelines to ensure that the projects funded with public resources: (a) make an additional contribution to technology transfer investment beyond what firms would have invested anyway; or (b) induce firms to engage in technology investments sooner, or perhaps decrease the time that would be required to perform a project; or (c) assist firms to complete their projects "better" than they might have been carried out without public funding.

Even without a formal procedural proviso, the issue of "additionality" might have been dealt with informally during implementation. For example, in the required pre-application interviews which scheme managers had with firms, the issue could have been raised. But a review of the notes from these interviews, and of the Project Information Sheets filed by TDS managers, indicates that no attempt was made to obtain information

that might establish a case for additionality. Moreover, during implementation, changes were adopted in TDS procedures which exacerbated the problem of ensuring that government funding was providing incentives for "additionality."

In the early stages of TDS implementation, there was an expressed concern in the TDS Supervisory Committee that the pace of disbursement of scheme funds was too slow. While scheme managers noted that firms were showing a good deal of interest in the scheme, they bemoaned the fact that submission of applications, and all the other paper work to obtain funding approval, were taking firms too long to complete. As a consequence of this concern, a "three-month rule" was put into effect, which made it possible to approve projects which had already started — as long as they had started "no sooner than three months before approval." The rule, as adopted by the Supervisory Committee, was to stay in effect through the first year of the scheme.

In its practical application, TDS managers often used the "three-month" rule to "informally" approve projects at the time of application, or even at the first interview, and then continued working with firms to get all the paper work completed prior to the three-month "formal" approval deadline. Despite a specified end date, this *modus operandi* of managing the grant-making process effectively continued throughout the life of the scheme.[8]

The net effect of the "three-month" rule was that the overwhelming majority of TDS' projects started before they were officially approved — some even before the first contact with TDS managers. TDS grant-allocation statistics indicate that 81 percent of the scheme's projects were started before approval: 56 percent were started even before a formal application was submitted, and 20 percent before the required first interview.

Providing subsidies for projects which have already started complicates significantly the problem of promoting "additionality." There is much less room to have an influence on additionality *ex post facto.* One is left with trying to assist firms in making improvements in the technology transfer project after they have formulated all the plans and, in many cases, ordered the equipment. Some might argue that approving

[8] TDS management stated that after the "three-month" rule ended about September 1995, a "one-month" rule was adopted in February 1996, but we could find no documentation of this change. It is clear, however, from the scheme's historical files that the practice of approving projects after they started stayed on as routine procedure through the life of the TDS.

grants after they started is okay because it is the presence of TDS that matters for firm decisions. Expectations mold firm behavior, and therefore the presence of TDS subsidies can induce firms to make investments before obtaining official approval, thinking that grants will be approved later upon request. This might have happened in a few cases, but it is rather risky behavior to have occurred on a large scale. One might also argue that most of the scheme's projects were not really started before approval. Scheme managers simply used the required first firm interview and the formal application as the final approval mechanism in order to short-cut approval procedures. If managers could show that short-cutting the approval process promoted "additionality" in some manner, there might be an argument for short-cuts. But this was not done. There is also a cost to short-cutting the approval procedures. Projects are not supposed to be approved until firms have submitted business plans, certified their financial solvency, and completed an acceptable terms of reference for consultants. These are formal entry requirements for scheme funding, stipulated by the Bank, to ensure that information is provided to assist in selecting the "right" projects.

Ensuring that public funds go to technology transfer investments that would not have been undertaken by the private sector is surely a difficult problem in practice. Even if procedures had been put in place to compel firms to certify that government funding promoted an addition to their technology transfer investments, such procedures would have been hard to enforce. As long as a firm says it would not have undertaken the investment without TDS, it passes the test. There is no independent way to easily verify the information. Hence, it is unreasonable to expect that TDS managers could have ***unambiguously*** determined the true state of affairs for every project. Moreover, it is difficult to conceive of a mechanism, which could have been utilized by managers, to ensure ***unambiguously*** that funding always would have gone to projects the private sector would not have funded on its own.

Despite such difficulties, however, what might have been done is to put in place procedures which made scheme managers and grant recipients explicitly aware of the principle of "additionality" and which required them, during implementation, to certify in each case that "additionality" had been *assessed*. At a minimum, this would have helped to screen out the egregious cases. It would also have constrained the manager's ability to

suggest short-cuts in administrative procedures. In addition, monitoring and evaluation procedures might have emphasized "additionality." Evaluations could have assessed whether, in a sample of project cases, firms had been induced by TDS subsidies to make investments they would not have made on their own, to make investments sooner, or to improve their technology transfer investments in some way.

Greater additionality might also have been fostered by TDS subsidies if scheme managers had adopted a more "hands-on" approach to grant-making. This would have required more visits to firms and closer cooperation with firms in formulating their technology transfer investment plans. As Table 2 indicates, only about two firms per month were visited over the life of the scheme and very few firms were visited more than once. A more hands-on approach would have facilitated working with firms to program a series of grants over time. Many firms we interviewed could have benefited from a series of grants to improve several aspects of their technology transfer investments or to make several complementary investments. In many cases, firms were turned away from getting a second grant because they were told that funds were running out and/or that the remaining funs had to go to firms who had not yet benefited from TDS.

Table 2: Visits to Firms

Year of first visit	***Firms visited for the***				*Total Visits*	*Of which follow up visits*
	First time	*Second time*	*Third time*	*Fourth time*		
1994/95	25	4	1	0	30	5
1995/96	27	11	2	0	40	13
1996/97	24	9	7	3	43	19
1997/98	27	3	2	0	32	5
Total	103	27	12	3	145	42

Promoting Large Economic Benefits…

The TDS was initiated, according to the Bank's Staff Appraisal Report, to foster technology transfer that would be useful to a wide array of firms across manufacturing, as well as to manufacturing service providers, in order to spur productivity growth and international competitiveness. TDS designers clearly expected that large economic benefits would result from the scheme, by way of direct benefits to firms receiving support for technology transfer investments and by way of indirect benefits to the rest of

the economy in the form of spillovers. How well did TDS do in selecting "good" projects and promoting the large economic benefits it intended to produce?

To begin, let's examine the allocation of TDS resources. Were they allocated to the intended target groups? A review of TDS grant statistics, together with information obtained from interviews with grant recipients conducted for this evaluation, show that TDS did a reasonably good job maintaining its focus on the scheme's target group of intended beneficiaries — manufacturing and services supporting manufacturing (see Table 3). In the early stages of TDS implementation, there was considerable pressure to open the scheme up to a wider set of activities. This pressure was moderated by a sensible Government/Supervisory Committee decision to allow a discretionary 10 percent of TDS grants to be made to other sectors (as it turns out, most of these grants went to the tourism sector).

Maintaining focus on the target group is important for maximizing the potential economic benefits of the scheme because: (a) it increases the potential for complementarities and mutually reinforcing positive spillovers among grants; and (b) it facilitates a concentration of the scheme's management expertise on a narrower set of economic activities where it can be most effective.

Table 3: Allocation of TDS Resources by Sector

	Manufacturing and Supporting Services			**Other**		
	No. of Projects	*Total amount ($)*	*Average grant size ($)*	*No. of Projects*	*Total amount ($)*	*Average grant size($)*
Total	218	2,003,318	9,190	6	134,750	22,458
%	97.32%	93.70%		2.68%	6.30%	

Within the intended target group, the TDS designers anticipated that more than 80 percent of the scheme's resources would go to EPZ firms, as these were the companies facing the most pressure from international markets to upgrade their technological capabilities. As it turned out, grant funds were distributed almost evenly between EPZ and non-EPZ firms (see Table 4). In terms of industry, the lion's share of TDS assistance went to textile and garments (about 50 percent), food processing and freight handling and shipping (another 25 percent), and the remainder to a range of other activities.

Table 4: Allocation TDS Resources by Status

	EPZ		Non-EPZ	
	Total	*%*	*Total*	*%*
No. of projects	117	52.23%	107	47.77%
Total amount ($)	1,150,304	53.80%	987,764	46.20%
Average grant size ($)	9,832		9,231	

As for the characteristics intended beneficiary firms, the TDS Manual of Policies and Procedures stated that, since the scheme constituted a demand-driven program, there would be no preference given to firm size or to location of the business operation. TDS Progress Reports and the minutes of Supervisory Committee meetings indicate, however, that there was a continuing discussion about increasing the number of grants to smaller enterprises. The stated logic behind the arguments for giving preferences to small enterprises was that small firms would benefit more than large firms: Large firms , it was argued, could afford the costs of technology transfer and small firms typically could not. In the end, the small firm debate does not appear to have shaped TDS resource allocation decisions very much. As Table 5 indicates, only 26 percent of TDS funds were allocated to small firms with fewer than 100 employees (20 percent to firms with fewer than 50 employees). Almost two-thirds of TDS resources went to large firms with more than 200 workers.

Table 5: Allocation of TDS Resources by Firm Size

	10-49 employees		50-99 employees		100-199 employees		200-499 employees		500 employees and above	
	Total	*%*	*Total*	*%*	*Total*	*%*	*Total*	*%*	*Total*	*%*
No. of Projects	65	29.02%	25	11.16%	35	15.63%	36	16.07%	63	28.13%
Total amount ($)	384,953	19.25%	133,500	6.24%	356,931	16.69%	517,619	24.21%	718,426	33.60%
Average grant size ($)	5,922		5,340		10,198		14,378		11,404	

One reason why more resources were not allocated to small enterprises was that the mechanism devised to facilitate their use of TDS did not work very well. TDS designers had foreseen the problems that might arise in working with small firms. Provisions were made in the scheme for "group projects," which could facilitate economies of scale in delivery of technology services and therefore reduce the cost of access of smaller

enterprises to technology transfer. In addition, grouping of firms could encourage synergy among firms and enable horizontal spillovers of technology to take place between them.

It is noteworthy that, in spite of setting up this mechanism for increasing the number of grants to small firms, not much progress was made in this direction. One of the reasons for this outcome was that group projects were largely taken up by larger enterprises (see Table 6). There were 13 group projects recorded in TDS files involving 37 firms. As Table 6 shows, these projects did not assist smaller firms very much in gaining access to technology — in fact, it was three times more likely that a group project participant employed more than 500 workers. The TDS management contractor offers the following explanation for this outcome in the TDS Final Report: "…it tended to be only the very small firms that were most interested in the financial savings offered by group projects, but such firms are typically difficult to organize into collaborative arrangements." In the end, group projects appeared to be useful for assisting large business organizations with diverse business interests, operating several manufacturing plants. These firms received half of the group project grants. Typically, the projects involved a technology, such as a new quality system, which was adopted by the parent company and diffused to each of the firm's manufacturing plants.

Table 6: Size of Firm in Group Projects and in All Other Projects

	Number of Employees				
Project Type	*Over 500*	*200-499*	*100-199*	*50-99*	*Below 50*
Group projects	62.5%	5%	5%	0%	27.5%
All other projects	20.65%	20.11%	16.3%	13.5%	29.35%

Source: Project records for firms' interviewed

Business support services for companies selling services to manufacturers were also eligible for assistance under TDS. Local commercial support services, such as shipping companies or business consulting firms, qualified for TDS grants "to upgrade or extend the range of services they could provide." A total of 39 grants were extended by the scheme to support services companies, representing about 17 percent of TDS resources. Freight shipping companies received 28 of the grants to these activities. Only 3 grants were provided to local consulting firms. As we will discuss in greater detail later

on, this very limited assistance to building the capability of local agents of technology transfer is noteworthy given the attention this aspect of the scheme received in the Staff Appraisal Report. It was the clear intention of TDS designers that technology transfer grants to manufacturers would stimulate market demand for local support service providers like consultants, and grants to consulting firms would assist in developing their capabilities to service this new market.

Finally, TDS managed throughout its implementation to confine its grants to the six priority technology transfer investments designated in the scheme's eligibility criteria. It had been determined before TDS began that these six areas represented the main technology weaknesses in Mauritian manufacturing, and therefore the best possible candidates for technology transfer assistance. Putting public funds to work supporting investments in these six areas was expected to reap the highest potential economic benefits. Table 7 indicates that productivity improvement and response-time projects received the largest share of resources.

Table 7: TDS Grants Distribution by Project Type

	New Product Design		New Tech To Export		Product Quality		Productivity		Quality System		Response Time	
No. of projects	16	7.14%	32	14.29%	20	8.93%	64	28.57%	62	27.68%	30	13.39%
Total amount ($)	133,960	6.27%	269,305	12.60%	195,456	9.14%	699,098	32.70%	415,802	19.45%	424,447	19.85%
Average grant size ($)	8,373		8,416		9,773		10,923		6,706		14,148	

In view of the fact that TDS resources appear to have reached their intended target, the next issue of interest is the valuation of the portfolio of grants that resulted. Was this portfolio in any meaningful way optimal for promoting the large economic benefits that were intended by TDS designers? While we will have more to say about this issue in our analysis of interviews with TDS-assisted firms later on, it can be noted briefly here that our review of TDS uncovered several weaknesses in design and implementation which suggest that a better portfolio of projects might have been selected within the designated target group.

Foremost among these weaknesses was the fact that TDS' eligibility criteria gave general guidance about the types of projects TDS should support, but provided no

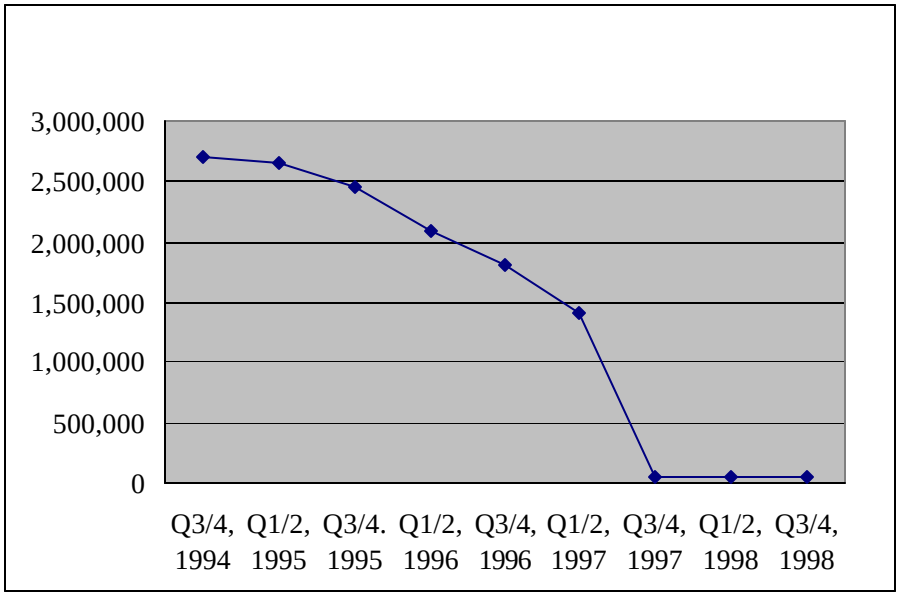
specific advice to TDS managers on how to differentiate among projects that met these criteria. In particular, there were no instructions on ways to differentiate between projects that would give large economic benefits to the economy and others. More specifically, the TDS criteria failed to establish a clear distinction between the *benefits to firms* that receive grants and the *broader economic benefits that society might gain* from the technology transfer projects supported by government funds. It was also never made clear that government support requires that only certain specific types of projects should receive public funds — those which have *higher economic returns* than the returns on other available public investments.

Without explicit criteria to assess the broader economic returns to projects, TDS funds were allocated on a first-come, first-served basis within the limits set by the eligibility criteria. Only scant attention was given to "selectivity" within these parameters. For the most part, as long as the firm was in the target group, the proposed project fit the five eligible project types, and the project was declared commercially beneficial to the firm, it was funded. A review of TDS records indicates that very few projects were ever rejected — only 12 applications were officially rejected over the four year life of the scheme (all of these on the basis of failing to meet the eligibility criteria, rather than any rationale based on the proposed projects' failure to meet expectations regarding broad economic returns) — and 34 projects were screened out in interviews before applications were submitted (most of these again for eligibility infractions). A few exceptional cases do appear in TDS files where arguments were made to justify or deny grants on the grounds of the expected returns to society. In one case, a firm was screened out in an initial interview, before submitting an application, because it was operating in a highly protected local market. In another, a grant was made to a prominent exporter to obtain ISO-9000 certification on the grounds that it would produce a "demonstration effect," inducing others to adopt ISO quality procedures. But, other than these few exceptions, there did not appear to be any pro-active selection of projects on the basis of the potential for generating large economic benefits to society. As the TDS manager told us, "…given the stated eligibility criteria, it was difficult to turn down a project as long as it fit."

Limited "selectivity" resulted in an exceedingly rapid disbursement of TDS resources. For all practical purposes, the scheme's funds were fully committed in the first two-and-a-quarter years of the four-year program (see Figure 2). Thereafter, projects with potentially high *economic* returns had to be turned away for lack of funds. Considering the scheme's overall resource limits, more selective grant-making might have produced a portfolio of grants that generated larger economic benefits.

More attention could have been paid by TDS managers to selecting higher quality technology transfer projects and selecting higher quality firms with a potential to drive future export success. Our survey of grant recipients turned up a number of questionable, low-return projects: for example, grants to highly protected domestic assemblers of consumer products with little ability or potential to export (or compete with imports given the size of the local market); grants for production troubleshooting rather than technology transfer; grants for adopting the same technology to different divisions of the same company or to different companies within the same business group; grants to a large foreign tobacco company with a local monopoly; and so on. None of these projects show much prospect for large economic returns to the economy. Our review indicates about 25 percent of the portfolio falls into this category.

Figure 2: TDS Fund Balance and Disbursement Progress (1994-1998)



Note: Due to unexpected exchange fluctuations, TDS ended up with about $500,000 undisbursed at the end of the project.

On top of this, there are indications that high return projects were turned away for lack of funds. Firms were told at the beginning of the second year of the scheme that TDS was running out of money and consequently they could not apply for a second grant. The pressure was increasing at this point to "spread the wealth" and give what remained of TDS funds to firms that had not benefited from the scheme. Very few firms, as a consequence, were able to work seriously with TDS managers to obtain a series of grants to complete a major technology transfer project, as mentioned earlier. TDS grant statistics indicate that only 3 or 4 firms were able to obtain grants equaling more than $50,000, no firm received the $100,000 limit (there were some business groups, however, whose firms received grants that add up to a bit more than the limit).

One is left with the impression after examining the TDS portfolio of grants and after talking with assisted firms that, given these problems, firms generally used TDS to fund bits of technology transfer projects already begun, to fund troubleshooting efforts, to fund the diffusion of technology to other divisions of the firm, and to fund the initial stages of technology transfer investments which would have to be completed by other means. Although these subsidies may have been helpful to firms, larger economic benefits could surely have been generated by greater selectivity and by giving more attention to working with firms through a series of grants to complete more important technology transfer projects.

For example, the fact that firms in most cases could not obtain a series of grants from TDS may have reduced their ability to maximize the benefits from new technology acquisition. The successful transfer of new technologies typically requires significant time and often necessitates a number of critical interventions by technical experts over this period. This is illustrated best by an observation made by a large Mauritian textile exporter, which was often repeated by many of the other firms we interviewed:

> "…moving up in technological capability requires a lot of outside technical expertise and in-house training. It normally takes one to one-and-a-half years to develop a new, higher-tech production line, during which you need almost full-time technical assistance. After the new line is created, you need more short-term assistance of one to three months to

make sure everything is working well. After two years, all is generally okay. If, on the other hand, you adopt a new production technology with only small bits of technical consulting and training, you have a problem. You may lose as much as 50 percent of your optimum efficiency."

More significant is the fact that lack of attention to the broad economic returns of technology transfer projects limited the scheme's potential for promoting knowledge and pecuniary spillovers. Positive knowledge spillovers (e.g., "demonstration effects" from the acquisition of new technologies) were noted in the Staff Appraisal Report as an important expected benefit of TDS subsidies. Moreover, it is the potential for positive spillovers that justify government involvement in funding schemes like TDS in the first place, as we noted in Section 2.

What types of spillovers could be expected from TDS subsidies? The simplest example is a knowledge spillover, which is generated when a firm improves its productivity by imitating the technology of another firm in the same industry that has made a new technology transfer investment with TDS support ("demonstration effect"). This is often called a horizontal spillover because knowledge spills over among competing firms in the same industry. Another kind of spillover occurs, a pecuniary spillover, when a supplier improves its productivity with a TDS technology transfer grant and the resulting lower product price or higher product quality spills over to other firms buying these products. This is generally called a vertical spillover because some of the effects of TDS' technology transfer subsidies accrue to firms (or consumers) within a vertical supply-chain by way of lower priced or higher quality inputs. Knowledge spillovers can also move along the vertical supply chain. Yet another type of spillover results when the technology upgrading of a firm, supported by TDS, leads to greater competition in the industry, so that rival firms are forced to search for new technologies or use existing technology and resources more efficiently ("competitive effect"). Still another type of spillover is generated when workers trained in a firm receiving TDS support leave to join another firm in the same industry or to the economy in general. Last but not least, improved managerial practices employed by firms receiving TDS

assistance, such as better quality management systems resulting from ISO-9000 certification, may spill over to other firms in the rest of the economy.

Since TDS did not deliberately select projects on the basis of promoting spillovers, any success of the scheme in generating such benefits is due to good fortune and the scheme's eligibility criteria, which directed grants to six specific types of technology transfer investments. Each investment type had the potential for generating positive knowledge and pecuniary spillovers, and some grants did, as we will show in the next section. But to maximize benefits from spillovers, TDS needed a more "strategic" approach to project selection within the parameters of the eligibility criteria. The scheme needed to develop specific guidelines on ways to differentiate between projects that would be appropriate for firms and those that would promote large spillovers and should be funded by government resources. As we noted earlier, firms have no incentive to propose projects that produce large spillovers and are appropriate for government funding. It was up to TDS managers to develop selection criteria that fit such goals.

Selection criteria with a strategic intent to promote spillovers might have emphasized three types of projects. First, more weight might have been given to projects which represented genuine "cutting edge" technology for the Mauritian economy. As we will detail in the next section, some of TDS' resources supported transfer of "cutting edge" technology, but only a few grants could be put into this category, according to our survey of projects. More grants for "cutting edge" technology projects might have promoted larger knowledge spillovers within industries.

Second, more attention might have been paid to projects within industry "clusters" of related and supporting activities. Nations, and industries within nations, succeed not because isolated firms succeed, but because "clusters" of related and supporting firms and industries, connected through vertical and horizontal relationships, succeed. Thus, the competitiveness of a garments firm depends not only on building up its own technological prowess, but also on the technological capability of upstream textile producers, downstream accessory producers, and other manufacturers in the supply-chain, like label makers and packaging producers, as well as supporting services, like shipping and handling. While it can be argued that some of TDS' grants did go to related

and supporting industries, the outcome was largely by accident and not by design. Much more might have been accomplished in promoting knowledge, and particularly pecuniary, spillovers, if attention had been paid in project selection to supply-chain relationships and the concept of industry "clusters."

Parenthetically, it should be noted that, in the case of a highly open economy like Mauritius, a good deal of the benefit from pecuniary spillovers goes abroad. Mauritian garments exporters may maintain or extend market share through productivity improvements in product price and quality, but foreign buyers reap most of the price and quality benefits accruing to consumers. One also needs to take into consideration the lack of linkages (forward and backward) in the Mauritian economy. A limited network of supply linkages reduces the opportunities for promoting spillovers within industry "clusters." Mauritius continues to be an exporter with a very narrowly concentrated range of products (more than 80 percent of exports are still concentrated in one product group — clothing). And within these products, a limited, although growing, set of related and supporting activities are linked to these exports. Many inputs are still imported because the Mauritian market continues to be relatively small.

Third, and somewhat related to the second point, more attention might have been given to the complementarities between TDS assisted projects. This is particularly important in promoting export diversification, a stated goal of TDS according to the Bank's Staff Appraisal Report. Particularly for diversification into the production of more complex industrial and consumer goods, ancillary and supporting industries are crucial. For example, without a mold-making technology investment to complement a technology investment in manufacturing higher-end watches, each of these projects would have a lower return.

Effective implementation of this more "strategic" and "selective" approach to grant-making would have required the TDS management contractor to operate differently. More industry-specific technical expertise would have been needed to work with firms and to scrutinize projects for their potential for generating positive spillovers. The home office of the TDS contractor would have had to back up the local TDS manager with real technical expertise, not just with short field trips to see how disbursement was going and to write Progress Reports. The TDS manager and TDS

technical experts would have had to work more closely with "leading" firms and with their business plans to make a series of grants to support the adoption of major new technologies, rather than spreading many small grants around to a multitude of firms. Lastly, the TDS manager would have had to examine the supply-chains and related activities of firms and industries to establish an effective strategy for promoting greater vertical spillovers.

4. Did The Technology Diffusion Scheme Create Incentives to Expand Economic Benefits?

Beyond choosing the "right" projects, TDS was designed to achieve some of its objectives by changing the incentives for participants so that they created more economic benefits. Incentives for stimulating the development and use of technology transfer support services and encouraging technology transfer to "take-off" and reach a "critical mass" that would sustain its future growth are among those TDS hoped to influence.

4.1 Stimulating the Development and Use of Technology Support Services

One of the central arguments in the Bank's Staff Appraisal Report for TDS revolved around the concern that "an active market in technology support services had not yet developed in Mauritius," and consequently "firms faced a steep learning curve in targeting and utilizing appropriate expertise." It was argued that TDS was needed, first, to assist in offsetting some of the costs of technology transfer and, second, to strengthen the mechanisms of technology transfer, in particular technical consulting services. Therefore, "stimulating an active market in technology support services…and promoting private-sector delivery of such services…" were among TDS' declared goals. Did the scheme's activities create incentives which stimulated such development, particularly in the market for local consultancy services?

Consider first the question of whether or not TDS motivated firms to use more expert consultants, some for the first time? TDS designers assumed from the beginning that firms in Mauritius had very little experience using expert consultants. It was flatly stated by the local TDS manager, for example, that "95 percent of firms in Mauritius had never used a consultant before TDS." To examine this issue, our interviews with firms

receiving assistance from TDS asked several questions about their experience using consulting services (prior to TDS assistance) and about their use of expert consultants after TDS (as one of the goals of TDS was to stimulate firms' use of consultants by underwriting an initial experience).

Survey results indicate that 78 percent of TDS-assisted firms had used consultants prior to receiving a TDS grant, and a number of these technical consultants had come from abroad. Most firms had paid full market rates for their consultants. Of the small group of firms having no experience with consultants prior to receiving assistance from TDS, one-half continued using consultants after the TDS experience, and, in each of these cases, they were paying full market rates. It would appear that the assumed inexperience of Mauritian firms in using expert consulting services was somewhat exaggerated (at least for the group of TDS-assisted firms). As a consequence, the impact of introducing firms to the new experience of using consultants by way of a TDS grant was somewhat limited.

However, there is evidence from the survey that TDS *did* assist these firms in at least three other ways. First, TDS grants helped firms deepen their experience in using expert consultants. Firms stated in several cases that the added experience, subsidized by TDS, taught them more about how to manage technical consultants effectively. Second, TDS helped firms underwrite the cost of obtaining consulting services sooner in the technology transfer process than they might have otherwise and also allowed firms to hire additional consultants in some cases and for longer periods of time. According to survey respondents, this additional use of consultants increased the productivity of their technology transfer investments, because these technical experts improved the firm's project planning, equipment installation, worker training, and final troubleshooting of the new technology.

It was also clear from our discussions with TDS-assisted firms that, although they may have used consultants prior to TDS, their experience was often rather limited and sometimes problematic. Even after the additional experience of using technical experts under TDS, firms continued to have concerns which made them cautious about hiring consultants: problems in finding *good* consultants; difficulties in defining a precise terms of reference for the consultant's services; and problems managing consultants to achieve

desired outcomes. Many firms stated that there were times when they did not know precisely what they needed until an expert consultant helped them determine their business problem or technical problem more precisely. Bringing a consultant on board sooner and for a bit more time allowed the consultant to get a better feel for the firm and its problems, which served to bring about a better definition of the firm's technology needs and allowed the firm's managers time to develop a more precise terms of reference for the consultant's future work. Such experiences, firm's noted, helped them learn more about managing consultants, especially in the difficult area of technology transfer, where the cultures of the transferor of technology and the recipient can be different.

Where TDS might have been more helpful is in assisting firms to source suitable consultants. At the outset, it should be noted that helping firms source consultants is difficult in practice and probably less likely to be successful than where firms can identify consultants themselves, through their customers or suppliers who can often nominate technical experts they know well. In many of these cases, the buyers or suppliers have a vested interest in the success of the project and are likely to nominate a consultant who would enhance their relationship with the firm. For many large firms in Mauritius, this is how they generally sourced consulting expertise. For many smaller and medium-sized firms without such contacts, TDS had to play a role in the process.

At the start of the scheme, the TDS management contractor claimed that it was compiling consultant databases from various sources, such as the UK Design Council and retired executive service organizations to build up an information base for firms to use in sourcing consultants. We found, however, that consultants from these sources were not used to any degree and the scheme's database only contained the names of some of these organizations with a few curricula vitae. Most of the contractor's efforts seemed to be devoted to gradually assembling a database of consultants by registering those consultants who applied for inclusion in the database, and by registering consultants who were nominated by firms. Over the life of TDS, scheme managers nominated eight consultancy firms from its database to 49 firms. This service was useful, particularly for smaller firms and for local consultants wanting to advertise their services, but its effectiveness was marred by the quality of the database at the scheme's disposal. Not only was the database limited in scope, but the quality of the curricula vitae of the

consultants registered was poor. The format and content of the curricula vitae varied greatly (whether of foreign or local consultants) and more than 60 percent of the curricula vitae were not up to the standards required in international tenders. As a consequence, it would have been difficult for firms to assess the experience and competence of the consultants nominated and to compare one consultant with another.

Turning to the second question, did TDS funding help to stimulate the market for private provision of technical support services? It is clear from our interviews with local consulting firms that TDS grants to manufacturers raised the demand for local consulting services in some activities. We spoke to several consultants who had provided services of one kind or another through TDS and they noted that TDS had stimulated market demand for their services and indicated that TDS had influenced some smaller service providers to start up their businesses. But it is evident that the local consulting market in Mauritius still remains very thin. Most of the consulting firms operating today offer limited services in areas such as accounting, management and management information systems, and quality systems. A manufacturer can find local consultants to help it become ISO-9000 certified, but generally has to look abroad for consultants in technical fields, such as production engineering, fabric dying, and tool and die making.

Several problems limited TDS' impact on the development of this local consulting market. The first was the duration of the scheme. The consultants we talked to were unwilling to make major investments in building up their capacity to serve a market that might dry up after TDS was over. TDS induced a few consultants to enter the market and provided opportunities for others to gain experience, and still others to branch out into new areas. But no consulting firm reported building a sustainable base on the TDS opportunity.

The second problem was the limited ability and experience of local consultants. An important reason why local consultants did not benefit more from TDS was their inability to sell additional services to companies. For example, once a local consultant completed a job assisting a company to obtain ISO-9000 certification, he/she typically had nothing more to sell. Large foreign consulting firms generally have a diversified staff with skills in a number of areas, and therefore can utilize the opportunity of an initial job to obtain work in other technical areas where the client needs assistance. This

is evidenced by the fact that local consulting firms with foreign connections were the most successful in obtaining repeat business from recipients of TDS grants. They were also the most successful at getting business from other clients after TDS ended.[9] Local consultants seemed reticent to overcome this problem by adding to their skill base through work-sharing agreements with other local firms.

One of TDS' stated goals was to assist local consulting firms in developing their capabilities to deliver services. Cost-sharing grants were supposed to be made available to private consulting firms to facilitate upgrading of their skills by way of training courses, partnerships with foreign firms, and learning-visits abroad. In particular, local consultants could have benefited enormously from partnership arrangements with more experienced foreign consulting firms — much would have been learned from mentoring and local firms would have been able to offer additional services in collaboration with the foreign firm, advancing their business prospects. Unfortunately, TDS records indicate that only three grants were ever given to local consulting firms. For reasons we could not discern, consulting firms were deemed ineligible for grants at an early stage of TDS' implementation, although clearly eligible under the scheme's Manual of Policies and Procedures and clearly in need of assistance.

Summing up, TDS did not have the impact expected by designers on the development and use of technology transfer support services. First, the scheme did not provide many firms with their first experience using consultants, most of the assisted firms had already had this experience. The scheme did, however, assist in deepening

[9] The most successful firm, in terms of the number of projects implemented, was SVS. This firm, a French firm with a Mauritius-based office, worked with 15 firms which were grant-aided by TDS. It had only worked with one of them before, but has continued to supply services to them all since TDS ended. Its point of entry to these firms was in the provision of ISO-9000 services, but its development of the market has been due to its ability to provide higher-technology services to these firms, particularly in the area of information systems management. SVS reported that it would have probably provided these services without TDS, but TDS helped SVS provide the services sooner. However, TDS did not give SVS the confidence to expand its business, as it noted it is "not worth building the capacity if the work will go away when TDS is gone."

It is interesting to compare the experiences of SVS with one of the most successful firms, Imani, registered as a local consultant. Imani undertook 8 TDS projects — principally ISO-9000 training. Imani previously had no ISO-9000 experience, but was introduced to a foreign ISO specialist firm that provided training to Imani in Europe and in Mauritius, and it was agreed that the foreign ISO specialist would provide inputs into the Imani projects. The Imani-assisted firms we interviewed were happy with its services, but Imani failed to retain any of them after TDS ended. This was because Imani had no other relevant services to offer its satisfied clients.

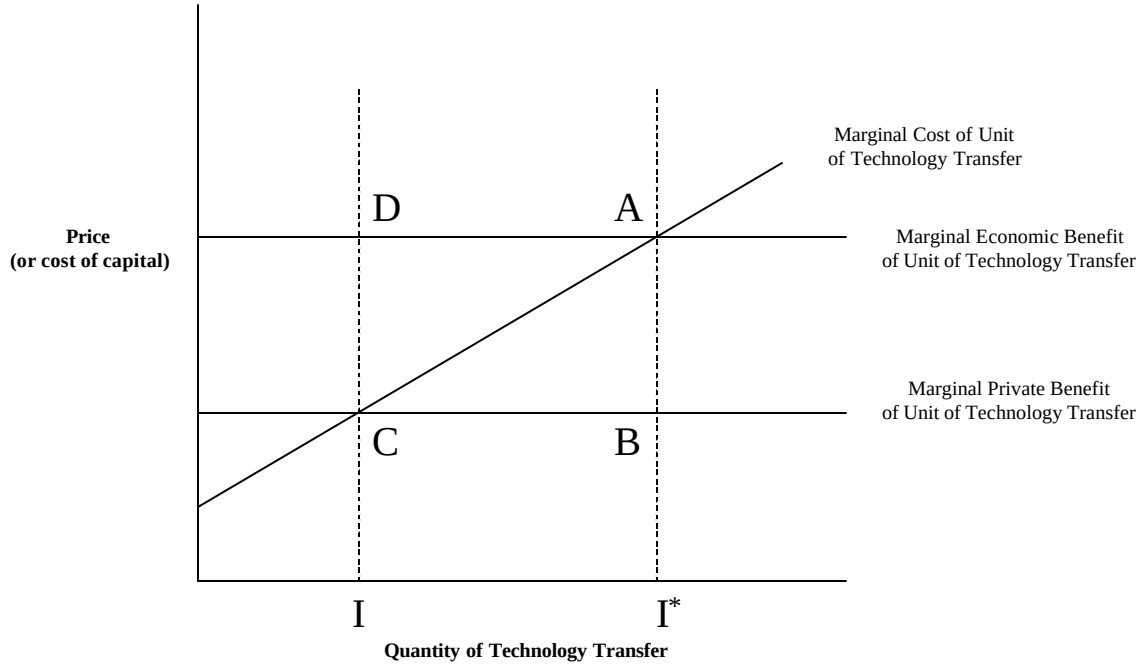
their experience in using consultants in many cases. Second, very few providers of technology support services benefited from TDS, which was unfortunate. Third, an active market for the private provision of technology support services does not appear to have received much stimulation from TDS activities. Only 14 of the consultants used by TDS grant recipients ever got much repeat business in the four years of the scheme, and only a few firms, which used consultants for the first time under TDS, ever employed consultants after the scheme was over. In addition, local consultants were generally unable to upgrade or extend their services — few obtained TDS grants to help them do so, and few successfully linked up with foreign consulting firms who could support them with mentoring and experience in providing wider or deeper services.

5. Did TDS Generate Positive Economic Benefits?

We turn now to an assessment of the economic benefits generated by TDS. Before we attempt to estimate these benefits, consider again the central rationale for TDS and the benefits expected from the scheme's subsidies. Figure 3 can be used to depict this rationale and to illustrate the economic benefits expected from government involvement.

Investments in technology transfer, as we indicated in Section 2, can create positive externalities in the form of knowledge and pecuniary spillovers to other firms and to consumers. As a consequence of such spillovers and the inability of investing firms to appropriate the full economic value of these benefits, the private sector will tend to invest less in technology transfer than is economically optimal. The positive externality is shown in Figure 3 as the horizontal *marginal economic benefit to society* line, which describes how much society values (or is willing to pay for) each additional unit of technology transfer investment and its associated spillovers. Because of positive spillovers, the marginal economic benefit to society from technology transfer is greater than the *marginal private benefit to investing firms*, which describes how much private firms value (or are willing to pay for) each unit of technology transfer investment. (The marginal economic and private benefit lines are drawn as perfectly elastic for ease of exposition.)

Figure 3
Public Provision of Technology Transfer Subsidies and Private (Counterfactual) Investment in Technology Transfer[10]



As Figure 3 indicates, private Mauritian manufacturing firms, given the presence of spillovers, would provide only up to (I) technology transfer investment on their own – up to point (C) where the marginal cost of technology transfer is equal to the marginal private benefit. The degree to which private technology transfer falls below the economic optimum, I^*-I, represents the amount of under-investment in technology transfer in the Mauritian economy which can be attributed to market failure. To keep things simple, we have not included here the problems on the cost side of technology transfer detailed in Section 2 — namely high search costs and other problems caused by uncertainty and information asymmetries, as well as other weaknesses in technology transfer mechanisms, which can raise the marginal *private* cost of technology acquisition above marginal *economic* cost depicted in Figure 3. In the presence of such additional costs and uncertainties of transfer, private technology transfer investment could be reduced below (I), as the private marginal cost of a unit of technology transfer would

[10] This figure is adapted from Devarajan, Squire and Suthiwart-Narueput, "Beyond Rate of Return: Reorienting Project Appraisal." The World Bank Research Observer, Vol. 12, No. 1 (February 1997), pp. 35-46.

intersect marginal private benefits to the left of point (C). We also do not consider capital market imperfections in Figure 3, which can further constrain technology transfer.

TDS was designed to provide the appropriate subsidy to Mauritian manufacturing firms to induce them to raise their technology transfer investments to more economically optimum levels.[11] The size of the subsidy necessary to bring forth the required amount of technology transfer, I^*, is AB in Figure 3, which equals the size of the externality (the sum of the knowledge and pecuniary spillovers) generated at the economically optimum level of investment.[12] Firms would be willing to pay the amount (BI^*), the additional cost required to achieve the economic optimum.

If we assume that TDS is implemented well — i.e., that scheme managers select projects with large economic (spillovers) benefits to society and fund only those projects that would not find private sector funding — then the appropriate subsidy (AB) should raise technology transfer investment up to I^*, and the net economic benefits of the scheme could be calculated as follows. In Figure 3, the total economic benefit of the scheme would equal area $DAII^*$, the area under the marginal economic benefits line between the amount of investment private firms contribute to the economy without TDS, — *the counterfactual* — and the economically optimum amount of investment brought forth by the scheme. The cost of public sector intervention is calculated as the additional burden TDS imposes on the government budget when firms pay the full amount they are willing to pay. The area under the marginal cost line between I and I^* is the total additional cost of the scheme, but since firms are willing to pay $BCII^*$, the additional cost to the government budget due to TDS is the area ABC. The net economic benefit of the scheme is therefore equal to the economic benefit, $DAII^*$, minus the total costs of the scheme (the cost to the government budget, ABC, plus the cost to firms, $BCII^*$), which is equal to ACD. In terms of the government budget, one can think of the cost-benefit ratio as ABC of public expenditure to bring forth ACD in economic benefits.

What happens to net benefits if TDS has any implementation problems? Take the most extreme case — assume that TDS grants simply "crowd out" private technology

[11] In addition, on the cost side, TDS was designed to reduce marginal private costs of technology transfer by creating incentives to stimulate the development of private mechanisms supporting technology transfer.

transfer investment. In this case, in terms of the counterfactual level of investment (I), no *additional* technology transfer is fostered. The *economic* benefits of TDS are zero under this scenario, and the cost of the scheme to the government budget remains the same, ABC. Therefore, the *net* benefits of TDS are negative (-ABC). TDS subsidies are simply used by private firms to fund technology transfer investments they would have made anyway (I), and the subsidies handed out by the scheme can be looked at as a transfer of wealth from taxpayers to the pockets of entrepreneurs. Comparing this worst case scenario with the previous best case scenario, it is clear that net benefit outcomes of TDS depend importantly on how well the scheme is implemented, and can range from (+ACD) to (-ABC).

The theoretical calculation of net benefits of a scheme like TDS is thus straightforward. In practice, however, there are some thorny problems in measuring economic benefits. The first, as already noted, is measuring the size of spillovers. The magnitude of spillovers created, which was assumed to be known in Figure 3 so that the appropriate subsidy could be determined, is difficult to observe in practice. Generally, one can obtain only an approximation of the actual spillovers generated by technology transfer investments. Another practical problem is obtaining a precise measure of the counterfactual level of technology transfer (I). It is difficult to calculate what would have happened without TDS. Yet another is assessing "additionality." TDS records provide no information on whether scheme grants actually promoted any "additionality." Nor do TDS records note whether grants promoted any economic benefits in the form of knowledge and pecuniary spillovers. The only information collected by the scheme, pertinent to an assessment of benefits, is the recorded data on project-specific and firm-specific "monitorables," which give some indication of the *private* benefits that accrued from TDS subsidies, but provide no data on broader economic benefits.

In order to improve these information problems, we surveyed a large random sample of TDS recipients for this evaluation. We also gathered information on a control group of Mauritian manufacturing firms which had not received TDS assistance. The survey of TDS-assisted firms solicited information on four basic issues:

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[12] We assume for purposes of exposition in Figure 2 that the exact size of the externality is known; so point (A) can be fixed. In reality, we cannot observe the exact size of the spillovers; hence, point (A) and I^* can

(a) "additionality" (Did TDS grants fund technology transfer projects that would have been financed by private firms themselves?); (b) "spillovers" (Did TDS grants generate large economic benefits for the economy?); (c) "extended benefits" (Did TDS grants create incentives that stimulated the development and use of local technology transfer support services?); and (d) "private benefits" (Did TDS grants produce private benefits for assisted firms?). Data on the control group of firms were collected to establish the counterfactual, and therefore focused on collecting information on investment and firm performance over the time interval of the TDS scheme and for several years before.

5.1 A Qualitative Evaluation of TDS Benefits

We begin with a qualitative impact analysis of TDS using the survey of TDS recipients. The analysis is qualitative in the sense that it involves a scoring of interview responses regarding the firm's perception of the level of benefits which accrued rather than a quantitative calculation of TDS' impact. A microeconometric, quantitative assessment of TDS benefits will be carried out in the next section.

Table 8 presents the results of the qualitative analysis. One hundred and four TDS-assisted projects were reviewed in the survey — about half of the scheme's grants. The projects are divided by employment-size of enterprise assisted. The first two columns of Table 8 contain the project number and type (one of the six technology transfer investments eligible for TDS assistance). The projects are listed by employment-size of enterprise assisted. The next thirteen columns provide a detailed qualitative assessment of benefits created by each of the TDS-assisted projects. Neither the TDS' project-specific monitorables collected by scheme management nor our interviews could obtain an exact measure of the monetary value of project benefits in each case, as we noted above. TDS grants financed only a small portion of the technology transfer projects carried out by assisted firms in most cases. Consequently, it was difficult to obtain a separate breakdown from the firms of the benefits produced by the TDS-funded component — generally the technical consultants, trips abroad, information search and the like — of the larger technology transfer investment. However, we were able to obtain

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only be estimated.

a qualitative assessment of the private benefits and, in some instances, the spillovers generated by TDS grants, as perceived by firms themselves.

"Additionality…"

The first column of the benefits section of Table 8, labeled "Additionality," contains an evaluation of whether or not the technology transfer project funded by TDS would have been undertaken by the firm without the scheme's support. That is, did TDS assistance induce firms to increase technology transfer investment beyond the amount I (the counterfactual) in Figure 3?

There are three elements to consider in this evaluation of additionality. First, TDS assistance may have stimulated firms to make technology transfer investments they would not have made otherwise. Second, TDS support may have encouraged firms to make technology transfer investments *sooner* than they might have. Even if assisted firms used TDS subsidies to make investments they would have undertaken on their own without TDS, making them sooner can create benefits for society that would not have occurred without the scheme. Third, TDS grants may have encouraged firms to improve their technology transfer investments. Again, the additional benefits, which would be generated by improvements in firms' technology transfer investments, would not have occurred without TDS. Each of these possibilities is considered under a separate column in Table 8. Our evaluation of "additionality" is based on firms' answers to questions soliciting direct information about these possibilities. For example, we asked firms directly whether or not they would have undertaken the project without TDS, or whether TDS induced them to invest sooner or better. Respondents' answers to these questions are recorded under each respective column — a (+) sign indicates a positive response to the question listed in each column.

A second element of information is also considered in this evaluation of "additionality" — TDS records on grant approvals and the dates firms indicated they started their technology transfer projects. As we noted in Section 3.2, TDS managers often short-cutted the scheme's approval procedures to speed up disbursement. Grants were routinely approved by TDS managers after the assisted firm's technology transfer project had started. As a result, more than 80 percent of TDS grants were approved after projects had started. Approving grants after the assisted firm's technology transfer

project has started raises serious questions about the scheme's impact on "additionality." Taking the most extreme view, one could say that 80 percent of TDS grants (78 percent of total TDS funds) simply "crowded out" privately financed technology transfer investment.

We adopted a less extreme approach in our analysis in Table 8. First, TDS grant approval records were reviewed to see when the firm's technology transfer project started and when it was approved by TDS. If it started before TDS approved the grant, then we turned to our interview responses to find out what the firm told us about additionality. If the firm said that it would not have undertaken the project without TDS assistance, then we set aside the approval information and assumed that the scheme's subsidy encouraged the firm to increase its technology transfer investment beyond what it would have done on its own. Conversely, if the firm's project started after TDS approval, but the firm said it would have done it on its own without TDS assistance, then we accepted the firm's word for it. If, on the other hand, both information sources indicated the project would have been funded by private means without TDS, then we looked again to our interviews for information on whether TDS could have generated economic benefits by inducing firms to invest *sooner* than they might have or *better*.

Beginning with the column labeled "Approval Procedures Compliance," which presents information on TDS grant approval records, Table 8 indicates that more than 80 percent of the projects reviewed in this evaluation started before TDS managers approved a grant (twenty projects out of 104 sampled received a score of 1, see the footnotes to Table 8 for an explanation of the numerical scores in the Approval Procedures Compliance column). This sample statistic is identical to what is found in the larger universe of TDS grants. Interestingly, the data indicate that the prospects for promoting additionality increased somewhat in the smallest firm size category (firms with fewer than 50 employees, for example, had 32 percent of their projects start after TDS approval, while only 4 percent of projects started after approval in the largest size category of 500+ employees). It would appear that small firms were more likely to acquire technology with TDS assistance.

Table 8: Project Eligibility and Benefits

Firm Number	*Project Type*	Project benefits												
		Additionality				Private benefits			Spillovers					
									Vertical		Horizontal			
		Approval procedures compliance (a)	*Will / Would not do w/o TDS*	*Do / Did sooner*	*Do / Did better*	*High (b)*	*Medium (c)*	*Low (d)*	*Knowledge (e)*	*Pecuniary (f)*	*Knowledge (g)*	*Pecuniary (h)*	*Extended benefits (i)*	
Firm size 0-49 employees														
1	QS	1	+			+				+			+	A
2	Pr	4					+							
3	Pr	1	+				+						+	B
4	PQ	2				+				+	+			
5	NT	2						+						
6	Pr	1		+	+	+							+	B
7	RT	3						+						
8	NT	4			+		+				+			
9	PQ	4	+			+					+			
10	NT	1						+						
11	QS	2						+						
12	NT	1		+			+		+	+	+			
13	QS	2		+			+							
14	NT	4		+	+		+							
15	NT	1	+				+							
16	PQ	2	+				+							
17	Pr	2						+			+			
18	NT	1		+			+				+			
19	NT	2		+		+			+	+				
20	NT	1	+				+							
21	QS	**		+			+		+	+			+	A
22	RT	3	+				+		+				+	B
23	NT	2	+					+						
24	Pr	2						+		+				
25	NT	2	+			+							+	B
Assessment of firms (% of total)			36	28	14	24	48	28	16	24	24	0	24	
Firm size 50-99 employees														
26	RT	3	+				+							
27	Pr	3						+						
28	QS	2			+	+				+			+	A
29	PQ	2	+					+						
30	PQ	2	+					+						
31	NT	2	+					+						B
32	PQ	3					+				+			
33	NT	2	+		+	+				4	+			
34	QS	3					+							
35	Pr	3		+	+		+							
36	RT	3		+			+							
Assessment of firms (% of total)			45	18	29	18	45	36	0	9	18	0	9	
Firm size 100-199 employees														
37	NP	1	+				+							
38	Pr	1			+		+						+	B
39	RT	4				+				+	+		+	B
40	Pr	4						+						
41	Pr	4		+			+							
42	NP	3						+			+			
43	NT	3			+		+							
44	PQ	3						+						
45	QS	1		+			+						+	A
46	Pr	2					+							
47	Pr	1	+			+			+					
48	NT	2				+					+			
49	QS	3	+	+		+							+	A
50	PQ	3												
51	Pr	4												
52	NP	1					+							
53	QS	NI					+						+	A
54	QS	3			+		+							
Assessment of firms (% of total)			17	17	16	22	50	17	6	6	17	0	28	
Firm size 200-499 employees														
55	PQ	3						+						
56	QS	4			+			+					+	A
57	NT	3					+				+			
58	Pr	4		+			+							
59	QS	1		+			+							
60	QS	3		+			+		+		+			
61	PQ	3				+			+					

Table 8: Project Eligibility and Benefits

Firm Number	Project Type	Project benefits												
		Additionality				Private benefits			Spillovers				Extended benefits (i)	
									Vertical		Horizontal			
		Approval procedures compliance (a)	Will / Would not do w/o TDS	Do / Did sooner	Do / Did better	High (b)	Medium (c)	Low (d)	Knowledge (e)	Pecuniary (f)	Knowledge (g)	Pecuniary (h)		
62	NP	3					+							
63	NT	3					+				+			
64	QS	2						+						
65	QS	1		+			+						+	A
66	Pr	1	+				+							
67	RT	1												
68	Pr	2				+				+			+	C
69	NP	3					+						+	C
70	Pr	1						+			+			
71	NT	4					+			+	+	+		
72	Pr	4					+			+	+			
73	QS	3			+		+							
74	NI	NI						+						
75	PQ	1					+				+			
76	Pr	1					+				+		+	B
77	QS	2			+		+		+		+			
78	QS	2	+					+						
79	Pr	2				+				+	+			
Assessment of firms (% of total)			8	16	14	12	60	24	12	16	40	4	20	
Firm size over 500 employees														
80	RT	2				+					+			
81	Pr	2				+					+			
82	QS	2					+							
83	Pr	1		+		+			+		+			
84	Pr	4	+				+							
85	Pr	2				+					+			
86	Pr	4				+					+			
87	Pr	3					+							
88	Pr	3				+					+			
89	NP	3				+							+	C
90	QS	4				+					+		+	A
91	Pr	4						+						
92	QS	4					+							
93	RT	3						+						
94	Pr	3					+							
95	PQ	3					+				+			
96	NT	2					+				+			
97	RT	2					+				+			
98	QS	3						+		+			+	A
99	Pr	2		+	+						+			
100	NT	3				+				+	+			
101	Pr	2		+	+		+				+			
102	NT	2	+				+				+			
103	QS	3			+		+							
104	RT	*					+				+			
Assessment of firms (% of total)			8	12	12	36	48	12	4	8	60	0	12	

Summary Evaluation of Firms by Size (Percent)

Firm size	*No of. Projects*	*Additionality*			*Private benefits*			*Spillovers*				*Extended Benefits*
		Not do w/o	*Sooner*	*Better*				*Vertical*		*Horizontal*		
					High	*Med.*	*Low*	*Kn.*	*Pec.*	*Kn.*	*Pec.*	
Firms 0-49 employees	25	36	28	14	24	48	28	16	24	24	0	24
Firms 50-99 employees	11	45	18	29	18	45	36	0	9	18	0	9
Firms 100-199 employees	18	17	17	16	22	50	17	6	6	17	0	28
Firms 200-499 employees	25	8	16	14	12	60	24	12	16	40	4	24
Firms over 500 employees	25	8	12	12	36	48	12	4	8	60	0	12
Percentage for all firms		20	18	17	23	51	22	9	13	35	1	20

Notes for Table 8
(a) "1" means the project started after approval, therefore additionality existed; "2" means the project started before approval but after the application was submitted; "3" means the project started before the application was submitted but after the firm contacted TDS the first time; "4" means the project started before the first contacted TDS the first time; '*' means the project started on the date when the application was submitted — before approval; "**" means the project's starting date = the application date = first contact date and all dates were before the approval date; "NI" means there was no information available about that project.
(b) Includes projects that significantly reduced costs, raised productivity or quality; lowered turnaround times; improved management and quality systems.
(c) Includes projects judged to have only average results in terms of costs, quality, response time, new technology, new product design, management or quality systems.
(d) Includes projects which failed to make an apparent difference in firm performance, did not transfer technology, or projects which were ineligible under the scheme's own selection criteria, e.g., local monopolies not exporting, firms with highly protected local markets.
(e) An evaluation of the extent to which the TDS grant introduced technology (production or management knowledge) which could strengthen the vertical value chain, e.g., buyers assisting in technology transfer, or be diffused down / up the value chain.
(f) An evaluation of the extent to which the TDS grant facilitated the acquisition of a technology which could lead to lower prices or higher product quality in the value chain, e.g., a packaging firm whose product prices drop due to new technology.
(g) An evaluation of the extent to which the TDS grant facilitated the transfer of a technology which would provide a "demonstration effect" for other firms in the same industry.
(h) An evaluation of the extent to which the TDS grant created competitive pressure, by way of price changes or product quality, on other firms in the same industry to adopt new technology.
(i) An evaluation of the extent to which the TDS grant created incentives for a broader or deeper market to develop in technology support services, e.g., if TDS grant raises the demand for consulting services, this might create incentives for local service providers to start up.

When we asked firms directly whether they would have *invested* without TDS (reported in the next column of Table 8), again 80 percent of the sample responded that they would have made their technology transfer investments on their own without TDS support. Smaller enterprises (fewer than 100 employees), were much more likely to respond that they would *not* have invested without TDS. Presumably, smaller firms suffer more from capital market imperfections and weaknesses in the mechanisms for technology transfer than larger firms, and therefore their investment decisions tend to be influenced more by TDS subsidies [as we will see later in this report, however, the "spillover" benefits to society created by the technology transfer investments of these small firms were found to be smaller than those of larger firms]. The large number of respondents claiming they would have invested anyway without TDS is not very surprising when one looks at how firms used the scheme's subsidies. Typically, TDS grants were for a small portion of a much larger technology transfer project — the average project size for assisted firms (including all the equipment, consultants, training and so on) was $350,000, while the average grant size was $10,000. The scheme funded part of the "softer" elements of the project — the consultants, training, and so on. One simply has to look at the aggregate investment numbers to get a feel for the relative insignificance of the TDS grant in most cases — within the group of assisted firms total TDS grants of $2.3 million represented just 0.5 percent of total firm investment over the four-year period of the scheme. Typically, as the numbers in Table 8 indicate, TDS grants were more important to smaller firms.

Thus, put together, the scheme's grant approval records and the survey responses strongly suggest that the scheme failed to promote much additionality. Even when we counter the information that projects started before approval with firm responses that they would not have invested without TDS assistance, only 14 TDS grants, which started before approval, can be shifted on to the positive additionality list. This raises the proportion of TDS-assisted projects, which can be counted as increased technology transfer investment above what would have occurred without TDS, to a bit more than 30 percent.

More credit might be given for promoting additionality if it could be shown that TDS subsidies induced firms to invest *sooner* or *better*. According to our interviews, 18 percent and 17 percent of the sample, respectively, indicated that TDS grants encouraged them to make investments sooner or better. Table 8 shows that smaller firms were stimulated a bit more than larger firms to make investments sooner. But, overall, TDS does not appear to have had a very significant impact on either category of additionality. We have no explanation for the fact that so few firms reported that TDS subsidies induced them to improve their technology transfer investments. One can only speculate that, if firms were making these investments on their own anyway, TDS assistance may have added value mostly as an additional source of funds, but not of expertise. The exception to this general observation might presumably be in the small firm category, where access to expertise is often constrained by both available financial resources and by information and ability to find and manage expert consultants. However, the survey data do not validate this assumption.

Benefits…

The qualitative evaluation of TDS benefits is divided into three categories as shown in Table 8: private benefits, spillovers, and extended benefits. We start with an assessment of private benefits based on our interview responses.

Private Benefits. Private benefits are the direct benefits that accrue to recipient firms from TDS grants. Since it was difficult to obtain a precise monetary estimate of the value of private benefits from our interviews, or from the TDS project-specific monitorable indicators, we developed qualitative indicators of the magnitude of private benefits based on private responses. Each project was given a qualitative score

irrespective of its additionality evaluation. Projects are scored "high", "medium", or "low" based on the private benefits firms indicated they gained from the TDS grant. High benefits were generated by TDS grants which helped the firm significantly reduce costs, raise product quality, lower production turnaround times, improve management and quality systems, and so on. Medium benefits were generated by TDS grants which helped the firm raise performance, in terms of costs, quality, response times, and management effectiveness, only moderately. Low benefits were generated by grants where consultants failed to make much appreciable difference in firm performance, where very little real transfer of technology occurred, or where the project was ineligible by the scheme's own criteria (e.g., a grant to a local monopoly producing a questionable product and not exporting, such as British American Tobacco, or a grant to a highly protected domestic producer with few prospects for exports or import substitution).

The results in Table 8 indicate that TDS funds appear to have generated significant private benefits for recipient firms. Seventy-five percent of the surveyed recipients reported realizing high or medium benefits from TDS grants. About one-quarter of the sample reported reaping high private benefits. This was balanced by another one-quarter of recipients that reported low benefits. It is interesting that neither high nor low benefit grants are correlated with the type of project carried out with TDS assistance. Each of the six types of projects eligible for TDS funding is represented in both lists. Significant differences in reported benefits are not observed across size classes of enterprise — all size classes appear to have realized private benefits from TDS assistance. The only exception is a slightly higher magnitude of low benefits reported in the smallest firm size classes. Our firm interviews indicate that smaller firms had more difficulty finding and managing expert technical consultants. This problem largely accounts for the poorer performance of some grants in this size class.

Spillover Benefits. Turning to the second category of benefits we evaluated — "spillovers." As we explained in Section 3.2, spillovers created by TDS subsidies can flow vertically from upstream suppliers to downstream buyers, or horizontally between producers. Moreover, spillovers can flow in the form of knowledge and ideas, or in the form of pecuniary "rents" which accrue from lower prices or higher product quality, or in the form of greater local competition. While knowledge and pecuniary spillovers can

generate positive or negative economic benefits depending on the form they take, we only assessed positive spillovers. Each of the spillover possibilities appears in separate columns in Table 8. Firms were asked to provide information on the potential types and direction of positive spillovers they thought were created by their technology transfer investments supported by TDS. A plus mark after each project indicates that positive spillovers were generated by the TDS grant, and placement under a particular column indicates type and direction of the spillover.

The survey data reported in Table 8 indicate that aggregate spillover benefits from TDS grants were relatively modest. As might be expected, vertical spillover benefits to the local economy (knowledge and pecuniary) are shown to be small because vertical linkages (backward and forward) remain relatively undeveloped in Mauritian industry. For example, most EPZ exporters operating today source only a few inputs from local companies — most raw materials and accessories are still imported. Vertical pecuniary spillovers are particularly small because, in a highly open economy like Mauritius, such "rents" accrue mostly to foreign buyers and consumers. Some vertical knowledge spillovers were evident in our interviews, especially in the case of TDS grants for quality system projects like ISO-9000. For example, we saw several cases where larger companies upgraded their quality systems or became ISO certified and the new quality management procedures spilled over to local suppliers, as they were forced to pay more attention to their own quality systems to meet the higher standards required by their large buyer.

The largest spillovers created by TDS appear to be in the form of horizontal knowledge flows between enterprises in the same industry. Adoption of new, cutting-edge production technologies and management systems by one enterprise seem to diffuse rapidly to other enterprises. We saw a number of cases in textiles and other sectors where new technologies, acquired with TDS assistance, had spilled over rapidly to other firms in the same industry. We also saw cases where adoption of new techniques by one firm in the industry put competitive pressure on other firms to upgrade themselves. Table 8 indicates that more than one-third of TDS grants created horizontal knowledge spillovers for other firms in the industry. Moreover, these spillover benefits to society appear to be correlated with firm size. Forty percent of grants in the 200-499 employee

firm-size category and 60 percent in the 500+ size category created spillover benefits, while less than 20 percent of grants in the smaller firm size categories created positive knowledge spillovers. This correlation of spillover benefits with firm size is not unusual. It is generally the larger firms in developing countries, with contacts abroad and with highly skilled labor, that import the lion's share of new production and management techniques. These new technologies are then diffused down through the size distribution of firms as the "demonstration effect" of using the new techniques helps spread the knowledge of their existence and adaptability to local conditions.

Before leaving the subject of spillovers, several points should be noted. First, the spillover estimates we provide in Table 8 are only approximations of the actual spillover benefits created by TDS grants — they may be underestimates or overestimates, we cannot observe their exact magnitude. Second, the mere fact that there are spillovers provides some justification for TDS subsidies. The amount of subsidy provided — i.e., the cost of TDS to the government budget — must, of course, be justified on the basis of the magnitude of the spillovers created, as we illustrated in Figure 3. In the case of TDS, the modest spillovers we observe do not appear to justify a sizable subsidy. Part of the problem is the distribution of spillovers between home and abroad. In an open economy, like Mauritius, where a significant proportion of TDS grants went to exporters, a large share of the spillover benefits accrue to foreigners. In this case, where a large part of the spillovers created go to the rest of the world, one should carefully assess the size of the government's financial burden to such a subsidy program. *Governments should only subsidize technology transfer up to the point where the marginal cost equals the marginal economic benefit accruing to its own nationals.* It is difficult without better information on the magnitude of spillovers, however, to assess what government's precise subsidy should have been in the TDS case. Finally, spillovers cannot always be considered "manna from heaven." Other firms may need certain capabilities to absorb them. In most cases, firms need some previous experience in acquiring new technology themselves to benefit from the spillovers created. In situations where very limited absorptive capacity exists in the rest of the economy, the spillovers created might produce only small benefits to society.

Extended Benefits. Extended benefits, the third category of benefits in our table, can also be considered spillovers created by TDS subsidies. However, they flow via more indirect channels, in that the scheme's subsidies change incentives for assisted firms, who, in turn, create additional economic benefits through their demands. As Section 4 noted, among the incentives that TDS attempted to influence were those affecting the demand for local technical support services, such as technical consulting. To evaluate the extended benefits generated by the scheme, we questioned TDS recipients about several aspects of their use of technical consulting services. Had the firm used technical consultants prior to TDS? Did the TDS-funded use of consultants change their incentive to use consultants in the future? Did the firm use consultants after the TDS experience? Did the firm pay full market rates for these consultants? A plus mark was given if a firm claimed that TDS-assistance had a positive impact on its incentive to use consultants in the future and the firm actually used consultants after TDS. A plus mark was also given for TDS grants to local consulting firms which were used to build up their technical capability to serve local clients.

Table 8 indicates that only about 20 percent of TDS grants can be said to have created any extended spillover benefits. As we discussed in Section 4 of this report, TDS did increase the demand for technical consulting, but, in the end, TDS was not a significant element in stimulating an active market for technology support services, and the survey data in Table 8 substantiate this conclusion. Few firms could say that TDS introduced them to expert consultants for the first time, and, as a result of this experience, that they continued to use consultants at market rates afterwards. Few local consultants could say that TDS made a significant impact on their long-term business prospects or that TDS-assistance helped to build their capabilities to serve local clients. But, while TDS subsidies were not very successful in stimulating the development of the local consulting market, however, they did assist some firms in learning more about using technical consultants, and they did provide a few firms with their first experience with consulting services.

It should be noted that our definition of extended spillover benefits here is somewhat narrow. TDS may have created some additional extended benefits which are quite difficult to capture even by a qualitative analysis. One of the most important

possible spillover effects which could have been derived from TDS grants relates to the *complementarities* in technology transfer investments. It is possible that a time-bound subsidy scheme like TDS encouraged firms to make complementary investments at the same time. The strategic interaction, or "complementary spillover effects," created by such investments could have generated broader effects, such as encouraging emerging infant industries to "take off" and to reach a "critical mass," or simply making each of the investments in related firms more profitable than they would have been on their own. Unfortunately, the fact that TDS had only limited success in promoting additionality reduces the possibilities for such added extended benefits.

5.2 Quantitative Evaluation of TDS Benefits

Our qualitative evaluation of TDS benefits is open to criticism on the basis that it involves subjective judgement and, in the end, does not arrive at an unqualified bottom line. A more definitive assessment of benefits requires a quantitative analysis. Therefore, as part of our evaluation of the impact of TDS, we collected data to conduct a microeconometric analysis of the payoff from the scheme.

This is not the first attempt to make a quantitative impact analysis of TDS. The TDS management contractor, in the scheme's Final Report, analyzed the impact of the scheme using the monitorable indicators of project benefits collected from assisted firms. The results of this analysis indicated that:

- TDS-assisted firms recorded an average increase in sales during the four years of the scheme of 134 times the total grant expenditure and an increase in exports 76 times total grant expenditure. This was far in excess of the "target benefit-cost ratio set for TDS" of 2 to 1.
- The average percentage increase in exports of TDS-assisted firms was more than twice the national average over the period.
- Only a small proportion of TDS projects (about 14 percent) failed to generate improvements in firm performance.

As one review of the TDS scheme put it after seeing these results, "The TDS apparently had a significant and positive impact on participating enterprises."[13]

The conclusions of the management contractor's report and the methods used to arrive at these conclusions provide a convenient example to illustrate some of the problems with these kinds of project impact assessments, as well as to emphasize the need for an econometric approach to evaluation studies. Let's go step-by-step through the contractor's analysis to point up the differences in approach and to elaborate the econometric method for evaluation used in this study.

Consider first the data used. TDS managers were only able to collect monitorables for about half of the scheme's projects. Without some information on the representativeness of the reporting firms, there is no real way to judge the direction of bias in the monitorables collected — average growth rates in sales and exports of this sample might overestimate or underestimate the payoff from TDS grants. For instance, one reason for the extremely large increase in sales and exports before and after TDS could be that firms were more likely to submit the relevant monitorables if their projects yielded satisfactory results. Even if we assume the monitorable data are unbiased, there appear to be too few data points — for all the projects, only one sales and one exports figure was collected before the TDS project started in the firm and only one data point was collected after the project ended. Growth rates based on the difference between the two data points might be subject to serious bias if either or both of the two points in time were abnormal for firms because of some transitory shocks which had nothing to do with the TDS project. To avoid such problems, one needs more observations on sales and exports for each firm both before and after the projects were undertaken. Moreover, the firm performance monitorables for the post-project period were generally collected within six months (some twelve months) after the TDS project was completed. Given the lag involved in realizing the benefits from a new technology investment, one cannot feel very confident that data collected so soon after adoption will capture the full impact of the TDS project.

[13] D. Crisafulli. "Matching Grant Schemes for Enterprise Upgrading: A Comparative Analysis. Private Sector Development Department, The World Bank.

A second issue is the methodology employed in the contractor's analysis. The conclusion that TDS was successful in raising assisted firm's sales and exports is based on a simple measure of the percentage increase in sales and exports before and after TDS assistance. But many factors other than TDS could have been responsible for this percentage increase in performance. What is needed is a counter factual analysis. The central question, as we have argued throughout this report, is what would have happened to firm performance in the absence of TDS? That is, in addition to a "before-after" analysis, we need a "with-without" analysis to separate the impact of TDS from the impact of all other influences on firm performance over the relevant period.

The ideal methodology for this is a difference-in-difference analysis, which compares the change in firm performance before and after the introduction of TDS with the change in performance that would have been achieved over the same period had the firms not received TDS subsidies. This counter factual outcome, of course, can not be observed. An alternative is to find a "control group" — a sample of firms that match the set of TDS recipients in terms of all observed and unobserved characteristics. Assuming that TDS assistance is the only factor underlying the difference between the performance of the TDS-assisted firms and the "control group" over the same period of time, one can safely attribute such difference to the impact of TDS.

A couple of practical difficulties must be faced in selecting an appropriate control group. Theoretically, if the firms receiving TDS grants were randomly selected from a large number of firms, then another random selection from the same pool of firms would yield an appropriate matching group. Thus, for example, if TDS grants were randomly distributed among the group of EPZ firms, then drawing a random sample of unassisted firms from the same EPZ group would yield an appropriate "control group." But what if TDS grants were not provided on a random basis? Considering that the TDS eligibility criteria selected projects on a "demand-driven, first-come-first-served" basis, it is not unreasonable to expect, for example, that the high performing firms — firms which might also be the most aggressive at seeking out subsidy schemes like TDS — got to the TDS door first. In this case, where grants went to the best performers, the randomness requirement for the TDS-assisted group (the "treatment" group) is not met — there would

be a "selection" bias in the data. One would have to construct a control group in this case according to the observed characteristics of this high performing treatment group.

Another difficulty that arises in using the outcome of the unassisted firms to estimate what the assisted firms would have experienced had they *not* been assisted, is spillovers. If the spillovers generated by TDS-assisted technology transfer investments were substantial, then it would be more difficult to randomly select a control group of firms, unaffected by TDS. In the presence of spillovers, the question arises whether the performance of the unassisted firms can be considered independent of the support given to the assisted firms. If spillovers are significant, there will be a bias in the estimated impact of TDS. For example, if the unassisted firms tend to benefit from knowledge spillovers coming from assisted firms, the impact of TDS may be underestimated.

Recognizing these problems of evaluating a grant scheme like TDS, we made the effort to assemble a firm-level data set that would improve on the analysis. For TDS recipients, we gathered data on firm characteristics (capital employed, labor employed, age of the firm, legal status, extent of outward orientation) which were possible determinants of performance (sales per employee). We also gathered a longer time-series on sales and exports. These time-series data provide conditioning variables which allow us to control for any pre-TDS performance abnormalities and temporary shocks that might influence the probability of being assisted by the scheme. Lastly, we gathered similar data on firm characteristics and performance for a control group of unassisted firms to facilitate estimation of counterfactual outcomes. The information on the control group and the treatment group allowed us to use the difference-in-difference method to quantitatively assess TDS benefits.

Data. The data for this analysis came from two sources: the Mauritius Registry of Companies and the Central Statistical Office of the Ministry of Economic Planning and Development. The TDS started in the last quarter of 1994. To facilitate a difference-in-difference analysis, we collected data that covered the period of 1992 to 1998 — starting three years before the beginning of the TDS. Data availability and a time constraint forced us to restrict our attention to firms with export processing zone (EPZ) status. EPZ firms contributed about half of the gross output of the manufacturing sector over our study period (ranging from 50.35 percent in 1993 to 50.87 percent in 1997); it was also

the stated main target of TDS assistance. Of 154 firms that participated in TDS, 74 had EPZ status and these EPZ firms had undertaken 119 projects, accounting for 53 percent of a total of 225 projects approved by TDS.

Most of the EPZ firms are in the textile and garments sector. Not surprisingly, among the 74 firms that formed our treatment group, 60 (81 percent) were textile and garment firms, while the other 14 (19 percent) belong to sectors such as chemical, electronics, agriculture/food processing, leather, plastics, and printing and packaging. Among 495 existing EPZ firms, excluding those that received TDS grants, we grouped the candidates by sector. In order for the control group to have the same composition of firms in terms of sector, we assigned the number of firms to be chosen from each sector in proportion to that of their counterparts in the treatment group. Therefore, we had 64 textile and garment firms and 16 non-textile firms in the control group. With the number of firms from each sector determined, we then randomly selected firms within each sector. Therefore, our control group matched the treatment group in terms of status (all are EPZs) and sector. The otherwise random sample of the control group allowed us to check if the firms that participated in the TDS were different than average firms.

For each firm on the list of the treatment group and the control group, we collected information on: date of incorporation, total exports, total sales, total employment, total fixed assets, net book value of fixed assets, investment in fixed assets, and depreciation of fixed assets for each year during the period of 1992 to 1998. The data were from the financial statements submitted by the firms to the Registrar of Companies each year. Because of missing files or firms' failure to turn in the required documents, we ended up with a little smaller sample: 68 firms in our treatment group and 75 firms in our control group. The information on employment and sector from the Central Statistical Office of the Ministry of Economic Planning and Development were then merged to the data from the Registrar of Companies for both the treatment group and the control group, while information on the year in which a firm took a TDS project together with the project amount were merged for the treatment group.

Model. Our microeconometric assessment of TDS benefits focuses on the benefits (derived from what can be called the "counter factual shift") to assisted firms.[14] Any

[14] See Appendix 1 for an equation setting out the full benefits and costs generated by TDS.

spillovers generated (beyond those which accrue to assisted firms) by TDS could possibly affect the control group, as we mentioned above. Given the available data, we test the hypothesis that TDS assistance positively influenced assisted firms' performance beyond what would have occurred without the scheme. Furthermore, in addition to assessing whether TDS had a positive impact on the performance of assisted firms, we also estimate the magnitude of private returns to each rupee of TDS assistance.

TDS grants subsidized the hiring of technical experts to assist in the transfer of technologies (including training), as well as trips abroad to learn about new technologies and to develop new markets. The recipient of the grant potentially accumulated a special type of capital by way of this assistance, which raised firm performance. A similar type of special capital is accumulated in the case of R&D investments [see Z. Griliches (1998) and T. Klette and F. Johansen (1998)].[15] Following the literature on evaluating the impact of R&D and other such technology investments, we use a production function approach and model TDS' impact as the accumulation of special capital. The econometric model is specified in Equation 1:

Equation 1: $$q_{it} = a_i + q_t + l_i + bk_{it} + g_1 p_{it} + g_2 p_{it-1} + ra_{it} + m_{it}$$

where q_{it} is log of sales per employee for firm (i) in year (t).

α_i is a firm dummy variable.

θ_t is a year dummy variable.

λ_i is a firm size dummy variable (SIZE).

k_{it} is the log of the capital labor ratio (LNKL).

a_{it} is log of firm (i's) age in year (t) (AGE).

P_{it} is a dummy variable which is equal to one if firm (i) received a grant from TDS in year (t) and zero otherwise (SCHEME).

P_{it-1} is a lagged dummy variable equal to one if firm (i) received a TDS grant

[15] Z. Griliches (1998). R&D and Productivity, The Econometric Evidence. Chicago: The University of Chicago Press. And T. Klette and F. Johansen (1998) "Accumulation of R&D Capital and Dynamic Firm Performance." Annals of the Economics and Statistics (49/50).

in the previous year and zero otherwise (LAG).

m_{it} is the error term.

All variables were deflated by the GDP deflator.

If TDS had a positive impact on the performance of assisted firms, then the estimated coefficient, (g_1), will be positive and statistically significant. The lagged dummy variable P_{it-1} is included to capture the possibility that it may take some time for TDS technology transfer projects to have an impact on firm performance. There is evidence from Griliches and Mairess (1984) that, for technology investments like R&D, there is a reasonably strong immediate effect on firm performance in the first two years, which then drops off and stays constant through most of the rest of the observable range. The firm-specific dummy variable (a_i) is included in the model to capture the effect of unobserved firm characteristics which do not change over time. The year dummy variable (q_t) captures any factors that influence the dependent variable across all firms in a specific year. Lastly, a firm size dummy variable is included to control for the influence of firm size on firm performance.

Table 9 presents the results of the multivariate analysis. The impact parameter, ("scheme"), is shown to have the right sign, but it is not statistically significant. The lagged impact parameter ("lag") is also not significant. TDS-assisted firms, in other words, do not outperform firms in the control group. Thus, it would appear that TDS did not achieve the desired result of producing enough positive *economic* benefits to justify the costs of the scheme. Why?

Probably the most important reason for TDS' failure to generate economic benefits is that the scheme failed to promote much additionality. We have already shown that grants were provided to many firms for projects they said they would have financed on their own. Hence, when we address the counterfactual question, we find that TDS-assisted firms do not perform much differently than they would have without the scheme. This is indicated by the fact that firms in the control group made a lot of technology transfer investments on their own over the TDS period. In fact, gross investment in the control group increased more than 50 percent during the life of TDS, while gross

investment in the treatment group of assisted firms increased by only about 20 percent over the same period.

Table 9: Multivariate Analysis of the Impact of TDS

Parameter	*Estimate*
LNKL	0.302***
	(0.026)
SCHEME	0.021
	(0.079)
LAG	-0.034
	(0.045)
AGE	0.055***
	(0.007)
SIZE1	0.354***
	(0.101)
SIZE2	0.159*
	(0.092)
SIZE3	0.080
	(0.074)
SIZE4	-0.031
	(0.088)
R^2	0.863

Note: Standard deviations are in parentheses.
*** = Significant at the 1% level.
** = Significant at the 5% level.
* = Significant at the 10% level.

On the issue of additionality, it is interesting that the multivariate analysis also supports the finding of our earlier qualitative evaluation which suggested that TDS grants had greater success promoting additionality in the smaller firm size categories (fewer than 50 employees). When the "scheme" variable is interacted with the firm size variable in the regression (not shown here), the parameter for the smallest size category is positive and significant. This indicates that small enterprises generally would not have invested in technology transfer projects without TDS.

Another reason for TDS' insignificant impact on economic benefits is the scheme's size. TDS grant resources of approximately $2.3 million (excluding management costs) amount to no more than one-half of one percent of total gross investment of assisted firms over the relevant period. TDS grants were spread across more than 150 firms with

an average grant size of about $10,000. Even if every TDS grant promoted additionality, the scheme would have to have had an extraordinary impact on firms, per rupee of subsidy, for the econometric analysis to pick up the effect.

A third reason for the low measured impact of TDS may be that the estimate of TDS benefits captured by the multivariate analysis is somewhat understated for two reasons. First, the impact parameter does not capture all the spillovers generated by TDS, as we noted above. The analysis picks up only the spillovers which influence the performance of assisted firms (the indirect effect in the first summation of Equation 1 in Appendix 1). Second, to the extent TDS subsidies generate spillovers outside this group, the estimated impact of TDS is biased downward, because the control group is possibly marked by the TDS-created externalities. Although, as we indicated in the qualitative evaluation of TDS benefits, TDS-generated spillovers are relatively small; hence this downward bias, if any, would be rather small.

TDS does not appear to have generated significant positive *economic benefits* for society, but what about the *private* benefits that accrued to firms receiving TDS grants? Our data allow us to estimate the *private rate of return* on TDS funded technology transfer investments in the group of assisted firms.. Following Griliches and Regev (1998), we estimate production functions incorporating the technology transfer capital accumulated with TDS funding, using the following equation:[16]

Equation 2: $$q_{it} = a_i + q_t + l_i + bk_{it} + gg_{it} + ra_{it} + m_{it}$$

where q_{it} is log of sales per employee for firm (i) in year (t).

α_i is the set of firm size dummy variables where Size 1 = 1-50 employees, Size 2 = 51-100, Size 3 = 101-200, Size 4 = 201-499, Size 5 = 500+.

θ_t is a time dummy variable.

λ_i is a sector dummy variable (SECT).

k_{it} is the log of the capital labor ratio (LNKL).

[16] Griliches, Z. and Regev (1998). "An Econometric Evaluation of High-Tech Policy in Israel." Paper presented at the Advanced Technology Program Conference, Washington, DC, June.

g_{it} is the log of the TDS accumulated capital which is calculated as the weighted sum of past and present TDS grants. The weights are a geometric series with different assumed obsolescence rates (15 percent and 30 percent) (LNGRNTA).

a_{it} is a log of firm (i's) age in year (t) and zero otherwise (AGE).

m_{it} is the error term.

All the relevant data for the treatment group of assisted firms used in this analysis are deflated by the GDP deflator.

The parameter of interest is (g), which can be interpreted as the private marginal rate of return on TDS-supported technology transfer investments. Table 10 shows the results of the analysis. The estimated marginal return parameter (technically, the elasticity of sales per employee with respect to grant per employee) indicates that there is a high and positive private rate of return on TDS funded technology transfer investments. When evaluated at the mean values of the dependent variable and TDS accumulated capital variable, one dollar of TDS subsidy generated a private return of 5.03 dollars[17]. If we assume a 15 percent obsolescence rate on TDS accumulated capital, then the return to TDS-supported technology transfer investments increases to 5.62 dollars.

One might suspect that this high private return is due to TDS providing grants to the best performing firms, producing an upward selection bias in the estimated rate of return parameter. To examine this possibility, we estimated a probit model looking at the probability of obtaining a TDS grant (see Table 11). The analysis finds that larger firms and firms with high ratios of investment per employee were more likely to get a TDS grant than other firms. Thus, there appears to be some indicated bias in the allocation of TDS grants. And, since investment levels and sales performance are positively correlated, there is reason to believe that some upward bias may exist in the estimate of private returns to TDS funding. However, even if we were to correct for the upward bias, it still remains that the private rate of return to TDS funding would be quite high.

[17] Marginal rate of return is equal to:

$$\text{Elasticity of Sales per Employee with respect to grant per employee } X \ \frac{\text{sales per employee}}{\text{grant per employee}}$$

The finding of a high private return on TDS funded technology transfer investments suggests that these investments should have been very profitable for the assisted firms. This indicates that TDS selected good, commercially viable technology transfer projects for funding, but raises the question whether such high return commercial projects might be too profitable to justify government support. As our earlier qualitative analysis shows, many TDS assisted firms would have invested in these projects on their own without TDS assistance, and such high returns provide the reason. Unless one can show that there are significant capital market imperfections affecting technology transfer investments, or significant information problems or other sources of market failure in the mechanisms for technology transfer, the evidence of such a high private return suggests that most firms should have been able to fund the technology transfer investments themselves.

Table 10: Estimation of the Private Rate of Return on TDS Funded Technology Transfer Investments

Parameter	*Estimate*
INTERCEPT	7.343***
LNKL	0.414***
LNGRNTA	0.017
AGE	0.002
SIZ1	0.035
SIZ2	0.106
SIZ3	-0.284**
SIZ4	0.211
SCHSIZ1	-0.030
SCHSIZ2	-0.022
SCHSIZ3	0.016
SCHSIZ4	-0.052*
SECT	0.097

Note: *** Significant at 1 percent
** Significant at 5 percent
* Significant at 10 percent level

Table 11: Probit Estimate of the Likelihood of Receiving a TDS Grant

Parameter	*Estimate*
INTERCEPT	-3.626**
AGE	0.010
SECT	-0.431
SIZ2	0.350**
SIZ3	0.696**
SIZ4	0.633**
SIZ5	1.031**
LNIL	0.127**
LNKL	0.109

Note: ** Significant at 5 percent

Appendix 1:
A Mathematical Expression of the Benefits and Costs Generated by TDS

Figure 3 illustrates that there are two types of benefits generated by TDS: Benefits to the private firms receiving TDS grants, and benefits to the rest of the economy in the form of spillovers to unassisted firms and to consumers. The equation below is a mathematical representation of Figure 3, which details the full economic benefits and costs which can be generated by TDS:

$$B(s) = \sum_{i \in S} \tilde{\Delta} p_i(s_i s') + \sum_{j \in N} \tilde{\Delta} p_j(s) + \sum_{l \in R} \tilde{\Delta} p_l(s) + \sum \tilde{\Delta}(CS) - d(s) \qquad (1)$$

All the variables on the right-hand side of the equation should be interpreted in terms of present values of current and future benefits. $\tilde{\Delta}$ is used to indicate the counterfactual shift in each of the variables. That is, each benefits term is measured as the net difference between the treatment group's and the control group's performance. Thus, if TDS subsidies "crowd out" private investment, then the counterfactual shift ($\tilde{\Delta}$) equals zero and the only term left is, *-d(s)*, representing cost of the scheme, and benefits from TDS, *B(s)*, are negative.

The first summation term in the ion 1 captures the change in profits in the TDS-assisted group of firms (*s*), due to the scheme. The benefit for each assisted firm can be decomposed into a *direct effect*, due to the grant they received (s_i), and an *indirect effect* capturing the change in profits due to TDS assistance received by other firms (s'). This indirect effect (or spillover effect) may be positive, negative, or zero depending on what kind of spillovers are present. The second summation term captures the change in profits in the group of unassisted firms, (*N*), in the same industry as the assisted firms. The sign of this *indirect effect* on unassisted firms will depend on the types of spillovers generated by TDS. As noted above, this indirect effect will be a mixture of knowledge and pecuniary (rent) spillovers. The third summation term captures the change in profits in

firms in the rest of the economy, (R), due, for example, to pecuniary externalities as inputs become cheaper or better quality. The fourth summation captures the benefits to consumers. Finally, the fifth term represents the deadweight loss associated with the funding costs of the TDS scheme.