

**Open Access to a Cultural Heritage:
An Economic Analysis of the SagaNet Project**

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Abstract

The SagaNet project consists of scanning, cataloguing and making accessible on the Internet Icelandic manuscripts and printed material on Icelandic and Germanic/Nordic literature housed at three locations: the National and University Library of Iceland, the Árni Magnússon Institute (AMI) in Iceland and Cornell University's Fiske Icelandic Collection (FIC). In all, about 350,000 pages were digitised, at the three institutions. In addition, 197,000 pages were catalogued at the National Library, and the catalogues at both FIC and AIM were updated and improved.

In this paper, the costs associated with setting up the SagaNet are discussed and statistical analysis used to estimate returns-to-scale and learning curves. It is shown that the project is unlikely to have much impact on current library and user costs, both private and social, but in the future additional expenditures will be necessary to maintain the sites and adapt the digital library to the changing technical demands of tomorrow. The major benefits to be derived from the project are the construction of improved, computerised catalogues and the creation of high-resolution digital images. In addition, the service enjoyed by prospective users will improve vastly. The digital images will also serve as backups to the original manuscripts and printed material, and will act as perfect substitutes for the originals. This should decrease the number of out-of-house manuscript loans, thus reducing transportation and insurance costs, as well as diminishing wear and tear on the manuscripts.

The SagaNet will also hopefully introduce new individuals to Icelandic Medieval literature and act as an important tool for those already familiar with the field, and should encourage interest in Iceland and Nordic culture in general

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1. Introduction

Iceland enjoys a special place in world literature. This recognition is mostly due to the richness of its medieval literature, first and foremost the Icelandic Sagas, family sagas written from the late 12th century until the 14th century. Other strands of Icelandic medieval literature include the Eddas, which deal with Germanic/Nordic mythology, and the history of Norwegian kings, contemporary sagas and tales from the European age of chivalry; as well as ballads, poetry and epigrams. This cultural heritage is preserved in written manuscripts, the oldest on vellum,¹ while younger manuscripts were written on paper. Most of the oldest and valuable manuscripts are preserved in the Árni Magnússon Institute in Iceland, while manuscripts written after 1650-1700 are mostly in the National and University Library of Iceland, but many precious items are also found in other libraries and museums.

Although a good deal of the text contained in these manuscripts has been published in books accessible to the general public, relatively few persons have gained admission to the manuscripts themselves, although quite a few visitors have viewed manuscript exhibitions. This has partly been due to the geographical location of the manuscripts, most of them are stationed in Iceland, and have thus been out of reach for all but dedicated amateurs and academics.

In 1997, the National and University Library of Iceland and the Fiske Icelandic Collection (FIC) at Cornell University with the association of the Árni Magnússon Institute (AMI) joined hands in the SagaNet project. The project consists of cataloguing and digitalising all manuscripts containing *the entire range of Icelandic family sagas, a very large portion of Germanic/Nordic mythology (the Eddas), the history of Norwegian kings, contemporary sagas and tales from the European age of chivalry.* These digital images and catalogues will then be made available to a worldwide audience on the Internet, see <http://www.sagnanet.is/>. Because every manuscript volume including the chosen subject is incorporated, the SagaNet will also contain a very large portion of other Icelandic medieval literature. All manuscripts, both on vellum and on paper from the

¹ Vellum is a fine kind of parchment prepared from the skins of calves or lambs and used especially for writing, painting or binding.

Manuscript Department of the National and University Library of Iceland and AMI, and printed editions and translations, as well as relevant critical studies published before 1900, from FIC at Cornell University will be included in the project.

The primary goal of the SagaNet project is twofold. On the one hand, it aims to stimulate research in Icelandic and Germanic/Nordic literature by making the manuscripts accessible to a greater number of interested individuals and by creating better, computerised catalogues than have hitherto existed. On the other hand, it aims to generate high-resolution digital images of the manuscripts that can serve as backups and substitutes for the originals. This may limit the need to handle the originals for professional purposes, thereby minimising the risk that the manuscripts will be damaged or lost.

All projects - and the SagaNet is no exception - come, however, at a cost, and this paper discusses the costs associated with setting up and running the SagaNet, as well as the potential benefits to be derived from the project. These costs and benefits are, unfortunately, difficult to convert into monetary values, and the discussion below will therefore consist, to a large extent, of pointing out which items should be included in the study, rather than estimating precisely the potential gains and costs in value terms.

The paper is organised as follows: The three project partners are described in Sections 2-4, while the project itself and the associated costs are studied in Sections 5 and 6. A statistical analysis of these costs is conducted, with primary emphasis on estimating a cost function and learning curve for the work undertaken at the National Library, in Section 7. Section 8 contains the costs-benefit analysis, and Section 9 concludes the treatise.

2. The Manuscript Department

The Manuscript Department of The National and University Library of Iceland was established in 1846, its core being the collections, dating back to the seventeenth century, of two Icelandic bishops and their forebears. Holdings have grown steadily ever since and now number about 15,000 single manuscripts or compilations.

The Manuscript Department is housed on the ground floor of the library building and has a reading room with 12 reading places. The manuscripts are kept in a vault equipped with special heat and humidity controls. The Department has a staff of four, all specialists in Icelandic literature.

The manuscripts must be used on the premises, although exceptions are made for those living far away from Reykjavik who can ask their local archives to borrow manuscripts, which must then be read in the archives in question. In addition, manuscripts are frequently loaned to AMI, for use by in-house scholars or visitors. Individuals cannot, however, borrow manuscripts. In order to limit wear and tear, the Department encourages patrons to use photographs or microfilms of the manuscripts instead of the manuscripts themselves.² All costs associated with photographing or making microfilms are borne by the Department itself and are not passed on to the user.

Although a printed catalogue of manuscript holdings is in existence, very little of the material within the Manuscript Department has been catalogued by modern, let alone machine-readable, methods. The catalogues often contain only a description of the contents of each manuscript, but do not mention where in the manuscript, e.g., on what pages, each item may be found, and are neither accurate nor comprehensive, as those involved in the SagaNet project have frequently experienced. Patrons may therefore have to spend a considerable amount of time searching the manuscripts for their items of interest, and they frequently seek advice and help from the staff on these matters. In addition, staff members are often requested to search manuscripts for material that is of interest to patrons who live far away from Reykjavik and are thus unable to peruse the manuscripts themselves.

Manuscripts for use on the premises can be reserved by phone or on the spot. The manuscripts are fetched from the vaults twice a day, so that patrons may, in extreme cases, have to wait a few hours for the manuscripts. Most patrons are, however, aware of the procedures and will therefore make the proper arrangements. As mentioned above, staff members often have to help patrons locate the material of interest within each manuscript. Many of the guests also have difficulties reading the manuscripts and often

² At present, only a few manuscripts exist on microfilms.

call upon staff members to help them decipher the writings. The service enjoyed by patrons can therefore be quite substantial.

The National Library is open to the general public and in the year 2000 around 1200 loans were registered at the Department of Manuscripts. Of these, it can be estimated that 10-20% were manuscripts containing material that will be made available on the Internet.

3. The Fiske Icelandic Collection

The Fiske Icelandic Collection (FIC) at Cornell University was established in 1905, at the bequest of Daniel Willard Fiske (1831-1904), who began collecting Icelandic books when he was a student in Sweden in the 1850s. At the time of Fiske's death, FIC totalled 8,600 volumes, but today the Collection includes more than 32,000 volumes and contains virtually every book printed in Iceland or written in Icelandic before 1930. It is the largest repository of printed works on Iceland and on Nordic medieval studies in North America, and thus extremely important for the study of Old Norse and Icelandic history, language, and literature, as well as being important for the study of medieval Scandinavia.

FIC is open to the Cornell University community for the loan of circulating materials. The non-circulating component of the collection, including rare items, is open for research to the University community and to non-University scholars and visitors. All books published prior to 1901, i.e. rare volumes, fall in the latter category and can only be examined in the reading room of the Division of Rare and Manuscript Collections (DRMC).

Most of the holdings in FIC are covered by the paper catalogues compiled by Halldór Hermannson and the OPAC for the University library. The former are available in the publicly accessible FIC reference shelves.

The service provided to patrons varies according to individual needs. Routine assistance consists of paging books from the vault, but some visitors, often those from Iceland, are also taken on tours of the vault. Internet reference is also available, and this can involve detailed research, simply because the patron is not present to pursue the research himself. Photocopying is possible with the permission of the FIC curator. It is also possible to

obtain, for a fee, copies of the microfilms generated during the NEH-funded preservation and access project from 1995-1997.

Typically, about 300 books per annum are borrowed from the FIC circulating component, but the number of guests who visit DRMC with the intent of researching rare FIC books has not been systematically collected. In addition, interested parties frequently pose questions via e-mail, and untold numbers have visited the circulating component of FIC, which is not visible from DRMC.

4. The Árni Magnússon Institute

The Árni Magnússon Institute was established in 1972, replacing and greatly expanding the former Manuscript Institute, which had been in operation since 1962. The Institute is formally a part of the University of Iceland, although it is managed and budgeted independently. As custodian of Icelandic manuscripts, both medieval and modern, the Institute has two principal roles: to conduct research relating to the manuscripts in its care and to other aspects of Icelandic culture and folklore, and to publish comprehensive critical editions of the manuscripts. While these editions normally consist of printed transcripts of the main texts, AMI also publishes facsimile editions of certain manuscripts. All such publications represent basic documents for further research or editions of these texts and are thus indispensable for scholars involved in the study of Icelandic or Old Norse language and literature. The Institute also publishes in its monographic series, doctoral dissertations, scholarly monographs, and articles on various aspects of Icelandic language, literature, and culture.

The AMI's holdings can broadly be classified into two components; manuscripts, and books and journals. Most of the manuscripts were previously kept in the Árni Magnússon Collection in Copenhagen and at the Danish Royal Library, but some of the manuscripts were also donated to the Institute or bought at auctions. In addition, the Institute always has manuscripts on loan from other collections, both foreign and domestic. It is also the policy of the Institute to possess negatives and photographs of all Icelandic manuscripts remaining in foreign collections. The manuscripts are kept in a vault equipped with

special heat and humidity equipment and monitors, similar to the one in the National Library.

The books and journals are housed in a research library, which is intended for use by the AMI's scholars as well as guests, academic, or non-academic, who are conducting research or who are interested in Icelandic literature. The library's holdings are not loaned out but can be used on the premises or photocopied.

Good catalogues exist of the manuscripts contained at AMI. The original catalogues date from around 1900, but in the year 2000 the Institute began to catalogue its manuscripts according to the new MASTER-standards (Manuscript Access through Standards for Electronic Records). Catalogues of many foreign libraries, that hold Icelandic manuscripts, are also available.

Although the Institute may in theory be open to all that are interested in Icelandic culture and literature, access to the Institute has in practice been limited to scholars who are conducting research in the field, and who must be within easy access of the original sources - the manuscripts - as well as other relevant books and journals. Visitors can also seek advice and share their thoughts with members of the Institute's staff, which includes a director and 10 specialists, two of whom are folklorists. Some of the visitors come from abroad, although most of them are Icelandic.

Guests at AMI have access to the library stacks, but must request manuscripts housed in the vault from library staff. Thorough records are kept of the manuscripts and all of them must be returned to the vaults each night. Photocopying of the manuscripts is not allowed, but patrons can obtain, for a fee, negatives and photographs of the manuscripts for research and publications purposes.

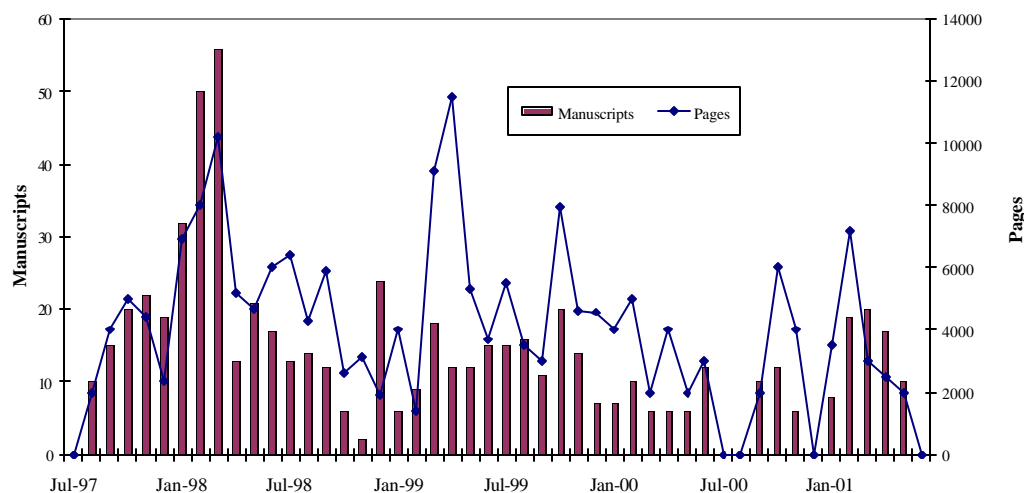
In the year 2000, 43 guests visited the Institute and it is difficult to estimate how many of these will choose not to do so once the SagaNet project has been completed and the manuscripts are available online. It is important to keep in mind that it is not only the manuscripts themselves that are of value to the visiting scholars, but the Institute and all its facilities, including library holdings and staff. Thus, online access may not compensate for the absence of books and journals, as well as stimulating conversations and consultations with specialists. In addition, the images on the Internet will not be of the same high resolution as the backups maintained by the Institute and may, therefore, not

be completely adequate for serious users. In what follows we therefore assume that the SagaNet project will not diminish the number of visitors to the Árni Magnússon Institute.

5. Cataloguing and scanning

In all, about 350,000 pages were digitised at the National Library, FIC and AIM. Computerised catalogues were also created at these three institutions. As noted earlier, good catalogues already existed at FIC and AIM, but the catalogues at the National Library left much to be desired.

Figure 1.
Number of manuscripts and pages catalogued per month at the National Library of Iceland.

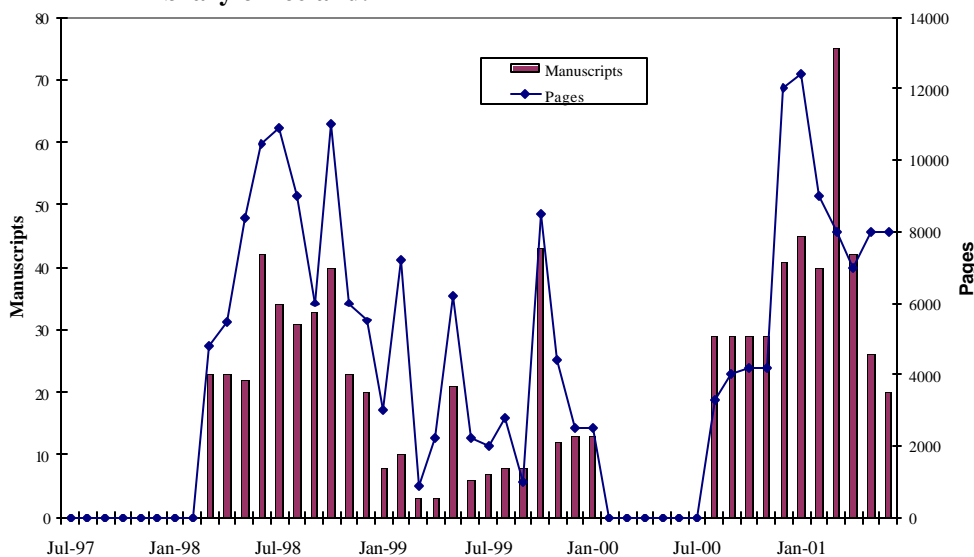


Work on cataloguing the library holdings for the SagaNet project commenced at the National Library in July 1997, but the first documents were not digitised until the following March. Cataloguing and scanning then continued uninterrupted until the beginning of the year 2000, when the digital camera broke down and was out of action for the next six months. Cataloguing was also halted twice during the summer and Christmas holidays in the same year. At the outset of the project it was also unclear how the catalogues should be constructed, and many items already catalogued had to be catalogued more thoroughly as it became clear that the original records were not accurate enough. Personnel changes also slowed down the cataloguing process.

In all, a total of 197,317 pages and 650 manuscripts were catalogued at the National Library, and 203,000 pages and 851 manuscripts digitised. The digitisation figures include approximately 37,000 pages of manuscripts from the Ární Magnússon Institute. On average, around 15 manuscripts and 4,500 pages were catalogued each month, and 25 manuscripts and 6,000 pages digitised. Months of inactivity because of technical malfunction or holidays are not included in these averages

The number of manuscripts and pages catalogued and digitised varied, however, considerably between months. Thus, the number catalogued in March 1998 and April of 1999 respectively was two to three times the average. Likewise, digitisation proceeded at a very brisk pace during the summer and autumn of 1998, as well as in the first months of 2001.

Figure 2.
Number of manuscripts and pages digitised per month at the National Library of Iceland.



Monthly records are unavailable for SagaNet project work performed at FIC and AIM, so that it is not possible to analyse the cataloguing and digitisation performed there in a manner similar to that above. At Cornell, just over 137,000 images were digitised from microfilm, with a further 14,000 images scanned directly. In addition, 453 items were catalogued at FIC and the catalogues updated.

Work on digitisation of manuscripts held by the Ární Magnússon Institute began in 1999. The Institute manuscripts were all photographed with 600 dpi resolution, which was

feasible because the total number of images was only around 41,000, 4,000 on vellum and 37,000 on paper. The vellum manuscripts were photographed at the Institute, while most of the paper manuscripts were photographed at the National Library, and are included in the figures for the Manuscript Department. The Institute also adjusted and completed the catalogue records included in the SagaNet.

6. Project costs

Total costs associated with the production of output can be broken into fixed and variable costs. Fixed costs are assumed to be independent of the rate of output during the period of study, and often arise because of decisions and commitments undertaken in some earlier period. As an example, interest payments and depreciation³ can usually be traced to the investments of previous periods, and these expenditures must be met regardless of the level of production in consequent periods. Variable costs, on the other hand, are only incurred when production takes place. Labour costs and material costs usually make up the largest share of variable production costs. It should be noted that in the long run all inputs are variable, and that the distinction between fixed and variable costs therefore depends crucially on the time horizon adopted.

Expenditures associated with setting up the SagaNet project can be roughly divided into investments, variable costs and other costs, which include the user evaluation study, economic study and various minor items. The investments undertaken fall into three categories: digital cameras, computer hardware and computer software. Variable costs are mainly labour costs and various computer costs not accounted for elsewhere. Fixed costs, such as expenditures on rent, heating and electricity, are not included in the SagaNet costs, as it proved impossible to separate the costs associated with the SagaNet project from other fixed costs of the three project members.

The total costs associated with the SagaNet project amount to \$1,277,000, whereof the lion's share, or \$1,045,500, was incurred at the Icelandic National Library. Costs at Cornell amounted to \$210,000, while costs at the Árni Magnússon Institute totalled \$21,500.

Table 1.
Itemisation of SagaNet costs.
Costs in thousand dollars.

	\$1,000	%
National Library of Iceland	1,045.5	81.9
Cornell University	210.0	16.4
Árni Magnússon Institute	21.5	1.7
Total costs	1,277.0	100.0

The National Library costs represent almost 81% of SagaNet expenses. That figure does, however, include the costs of digitalising most of the paper manuscripts from the Árni Magnússon Institute. Variable expenses, including labour costs, amounted to \$657,200, while investments totalled \$303,200. Costs associated with the economic study undertaken by the Institute of Economic Studies at the University of Iceland were \$70,500, and other costs totalled \$14,600.

Table 2.
Itemisation of SagaNet costs incurred at the
National Library of Iceland.

	\$1,000	%
Variable costs	657.2	62.9
Investments	303.2	29.0
Economic study	70.5	6.7
Other	14.6	1.4
Total costs	1,045.5	100.0

Average variable costs associated with cataloguing were \$866 per manuscript and \$2.4 per page, while the average variable digitising costs came to \$225.5 per manuscript and \$0.8 per page. These costs vary a great deal, as is shown in Figures 3-6. Average costs for cataloguing a manuscript peak in November 1998 at \$5,089.4, six times the average, while costs for cataloguing a page are highest in February 1999, \$7.8, almost four times the average. The highest average monthly costs for digitising a manuscript are observed in March and April 1999, \$953.7, which is almost four times the average, and the highest average costs for digitising a page occur in September 1999, \$4.8, six times the average.

³ It is assumed here that depreciation only depends on the passage of time.

Figure 3.
Average costs for cataloguing a page at the National Library of Iceland. US dollars.

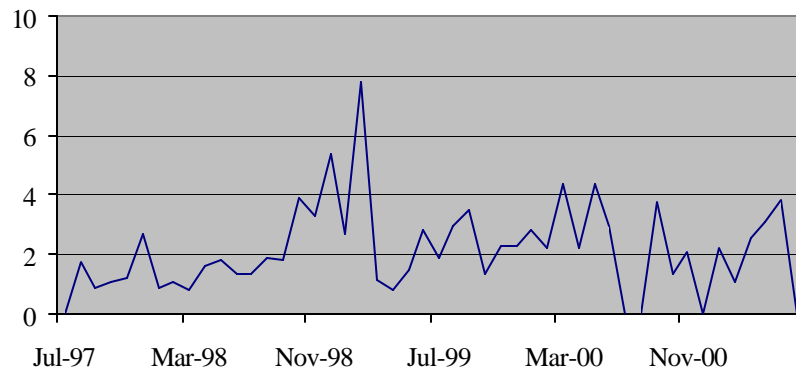
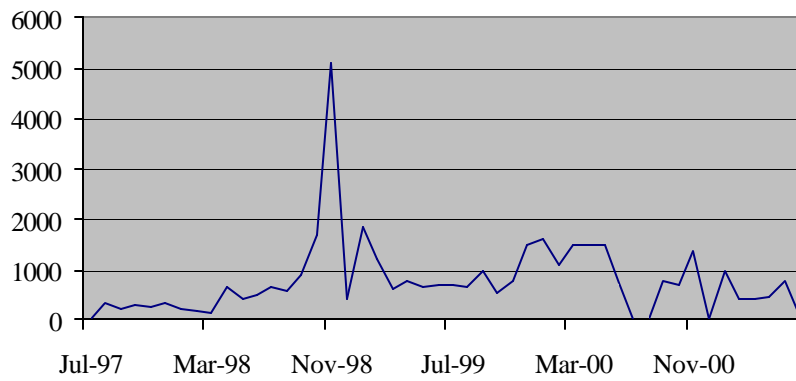
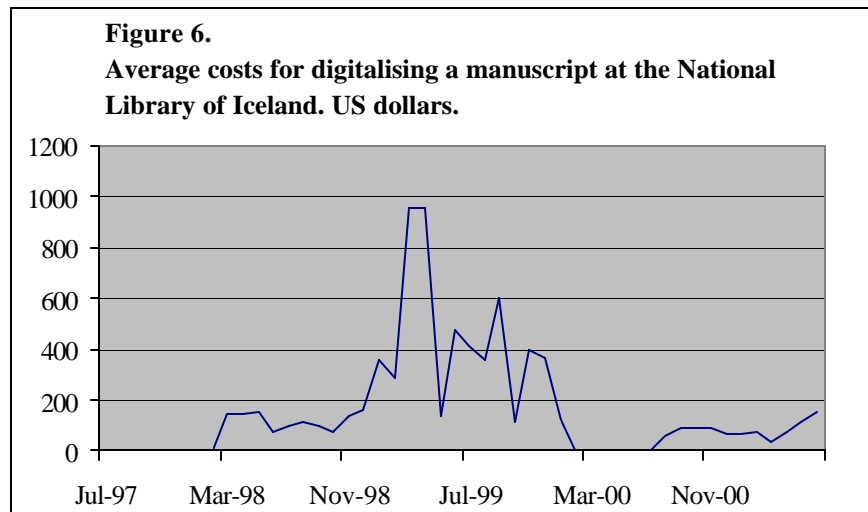
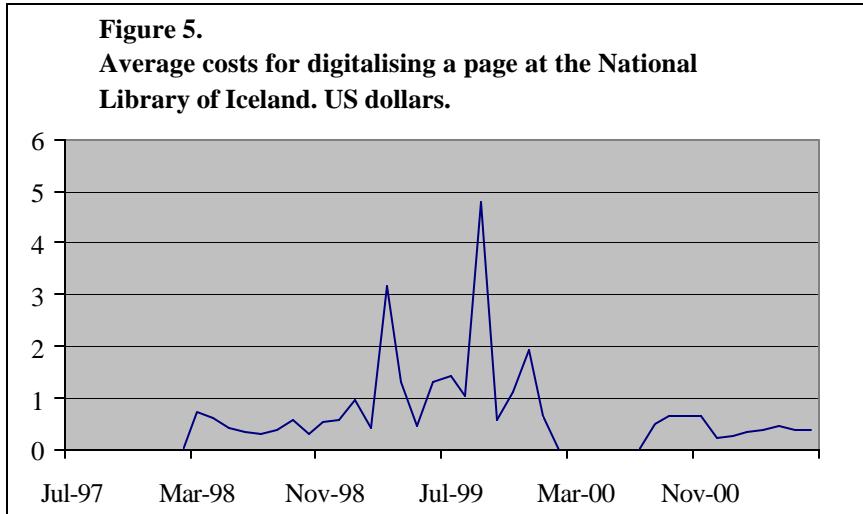


Figure 4.
Average costs for cataloguing a manuscript at the National Library of Iceland. US dollars.



Figures 3-6 also reveal that average costs do not appear to have declined much through time. Indeed, average costs for cataloguing manuscripts and pages were higher during the first six months of 2001 than they were in the first six months of the project. However, the reverse holds true for the digitising.



The SagaNet project paid \$210,000 to the Fiske Icelandic Collection at Cornell University. Costs associated with converting microfilms into digital images and scanning amounted to \$70,000, with a further \$51,444 spent on system development and \$50,198 on hardware and software. The user evaluation study cost \$28,455 and travel expenses totalled \$9,903. In all, 151,000 images were digitised at Cornell, and total costs per image therefore averaged \$1.39. Variable costs, i.e. only conversion costs, per image amounted to \$0.46.

Table 3.
Itemisation of SagaNet costs incurred at
Cornell University

	\$1,000	%
Conversion costs	70	33.3
System development	51.4	24.5
Economic study	70.5	6.7
Equipment	50.2	23.9
User evaluation	28.5	13.6
Miscellaneous	9.9	4.7
Total costs	210.0	100.0

The SagaNet project paid the Árne Magnússon Institute \$21,500, whereof \$14,500 were used for the purchase of a Dicomed 7000 Digital Camera with an array of 5200 x 7500 dots, and \$7,000 on training and set-up costs. This camera was used mainly for digitising the vellum manuscripts. As mentioned above, all the vellum manuscripts were photographed at AMI, while most of the paper manuscripts were digitised at the National Library and all relevant costs thus incurred there. Costs associated with cataloguing and digitising the vellum manuscripts at AMI were not separated from other Institute costs, and we are therefore unable to estimate average cataloguing and digitising costs at AMI.

7. Cost functions and learning curves

According to economic theory, production costs depend on the level of output and prices of inputs. In the short-run, technology can be assumed to remain constant, but through time technical advances usually lead to declining costs. This relationship between costs, output, prices and technology has been formulated in the following cost function:

$$(1) \quad C = C(P, Y, A)$$

where C represents costs, P a vector of the relevant input costs, Y output and A the state of technical knowledge at any point in time.

Cost functions are assumed to satisfy certain properties, some of which are stated for mathematical convenience while others are based upon economic principles.⁴ Among the latter are the assumptions that a positive output cannot be produced at zero costs and that increasing input prices can never decrease costs. Similarly, increasing production will never decrease costs. It is also assumed that all inputs are variable so that no costs are incurred when nothing is produced. Further, increasing all input prices by the same proportion will increase costs correspondingly, since no substitution between inputs will take place if relative input prices remain unchanged. Put differently, it is assumed that the cost function is linearly homogenous in input prices.

Of special interest to us here, is the relationship between the amount of output produced and costs. This relationship is referred to as the cost elasticity, $n(P,Y,A)$,⁵ and can be defined as:

$$(2) \quad n(P,Y,A) = \frac{\partial C}{\partial Y} \frac{Y}{C}$$

A cost elasticity of unity implies that increasing output by a certain percentage will lead to proportional increase in cost. A value of less than unity indicates that output can be expanded without a corresponding rise in costs, and vice versa.

All cost functions are dual to an underlying production function, where the latter specifies the relationship between the amount produced and the quantity of inputs used in the production process. Formally, the production function can be written as:

$$(3) \quad Y = Y(X, A)$$

where Y and A are defined as above, but X represents a vector of inputs. The relationship between input usage and production is characterised by the term economies of scale. A production process is said to exhibit constant-returns-to-scale if increasing all inputs by the same percentage will lead to a corresponding increase in output. Increasing returns

⁴ This is discussed in several modern treatises on microeconomics. See, for instance, Chambers (1988), Cornes (1992) and Varian (1992).

are said to exist if output increases more than proportionally, and decreasing returns if output increases less than proportionally.

Under certain conditions, it can be shown that the inverse of the cost elasticity will equal the scale elasticity.⁶ The scale characteristics of the production function can then be gauged by using statistical methods to estimate a cost function, and subsequently calculate the cost elasticity of the function.

Empirical studies have frequently observed that unit production costs tend to fall over time as production accumulates. Workers often learn from their experience, and in some cases, even manage to improve the production process.⁷ This holds especially true for various assembly line operations, but has also been observed in other activities. The relationship between average costs and accumulated production has been referred to as the learning curve in the literature. A well-known historical example concerns certain emergency shipbuilding yards that were involved in the construction of the class of vessels called Liberty ships during the Second World War. Unit costs fell drastically in these yards when production accumulated, despite the fact that the annual level of operations remained unchanged.

There are a number of ways to formulate the learning curve, but the simplest and most common form is:⁸

$$(4) \quad c_t = c_1 n_t^{\mathbf{a}_c} e^{u_t}$$

where c_t denotes real average real costs of production in time t , c_1 represents real average costs in the initial production period, n_t the cumulative number of units of output produced up to time period t , \mathbf{a}_c the elasticity of unit costs with respect to cumulative volume, e the exponential operator and u_t a stochastic disturbance term reflecting the inherent randomness in cost-production processes. Applied studies frequently find that \mathbf{a}_c is negative, indicating that average costs fall as production accumulates. For empirical purposes it is convenient to rewrite equation (4) in logarithms as:

⁵ The cost elasticity is also referred to as the cost elasticity of output and cost flexibility.

⁶ See Chambers (1988), pp. 69-74.

⁷ As defined here, learning by doing is synonymous with exogenous technical change.

$$(5) \quad \ln c_t = \ln c_1 + \mathbf{a}_c \ln n_t + u_t$$

The learning curve parameter, \mathbf{a}_c , can now be estimated by standard econometric techniques, provided, of course, that the appropriate data are available. The first term, $\ln c_1$, can also be simply estimated as the intercept.

Learning curves can also be derived from cost functions. Consider, for instance, a logarithmic version of the commonly used Cobb-Douglas cost function:

$$(6) \quad \ln C_t = \mathbf{b}_0 + \sum \mathbf{b}_i \ln P_{it} + \mathbf{b}_y \ln y_t$$

where \mathbf{b}_0 , \mathbf{b}_i , and \mathbf{b}_y , are parameters to be estimated and i denotes input i . To ensure linear homogeneity in input prices it is assumed that $\sum \mathbf{b}_i = 1$, which, in the case of single input, implies that the parameter associated with that input takes on a value of unity. For the data at hand, the latter seems a reasonable formulation, since variable costs incurred in cataloguing and digitising at the National Library of Iceland, were almost entirely made up of labour costs.⁹

Assume further that the effects of technical change can be captured by the term for cumulative production in equation (4). The Cobb-Douglas cost function for a single input can then be written as:

$$(7) \quad \ln C_t = \mathbf{b}_0 + \ln P_t + \mathbf{b}_y \ln y_t + \mathbf{b}_n n_t.$$

where P , the price of variable costs, is represented by the wage index for regular salaries of permanently employed civil servants in Iceland. Average real costs equal total costs deflated by a price index and divided by total output, i.e.

⁸ See Berndt (1991), pp. 72-73.

⁹ Labour costs constituted between 98 and 100% of the variable cataloguing costs and between 92 and 100% of the variable digitising costs.

$$(8) \quad c_t = \frac{C_t / P_t}{y_t}$$

or taking logarithms

$$(8') \quad \ln c_t = \ln C_t - \ln P_t - \ln y_t$$

It therefore follows that equation (7) can be rewritten as

$$(9) \quad \ln c_t = \mathbf{b}_0 + \mathbf{b}_y^* \ln y_t + \mathbf{b}_n \ln n$$

where $\mathbf{b}_y^* = \mathbf{b}_y - 1$. In the case of constant returns to scale, the parameter \mathbf{b}_y takes a value of unity and the parameter \mathbf{b}_y^* therefore a value of zero. The hypothesis that \mathbf{b}_y^* equals zero can then be tested using standard statistical tests. Needless to say, the parameter \mathbf{b}_n equals the parameter \mathbf{a}_c in equation (2).

Equation (9) is, of course, very similar to the learning curve in equation (4), the only difference being the additional output variable included in the former. The two equations were estimated for the four different tasks performed at the National Library of Iceland; cataloguing of manuscripts and pages, and digitising manuscripts and pages. A third equation was also estimated, as special variant of (9) where \mathbf{b}_y was restricted to equal zero. For the purpose of estimation, a stochastic error term was also appended to each equation. The three equations estimated are thus:

$$(10a) \quad \ln c_t = \mathbf{b}_0 + \mathbf{b}_n \ln n_t + u_t$$

$$(10b) \quad \ln c_t = \mathbf{b}_0 + \mathbf{b}_y^* \ln y_t + u_t$$

$$(10c) \quad \ln c_t = \mathbf{b}_0 + \mathbf{b}_y^* \ln y_t + \mathbf{b}_n \ln n_t + u_t$$

Costs are in all cases defined as variable costs, which consist almost exclusively of wages and other labour costs, and are deflated by the above mentioned civil servants wage index. Output is defined as the amount catalogued or digitised during the month in question, and cumulative output measures the total amount catalogued or digitised in the previous month.

Table 4.
Parameter estimates of learning curves and cost functions. Cataloguing of manuscripts and pages.
The independent variable is real average cost. Number of observations is 43.

	Cataloguing of manuscripts			Cataloguing of pages		
	I	II	III	I	II	III
Constant	13.2279** (0.1398)	8.7919** (0.7574)	12.2078** (0.2886)	13.0452** (0.2816)	2.8157* (0.9508)	11.004** (0.5921)
Current output	-0.9835** (0.0306)		-0.9804** (0.0277)	-0.9722** (0.0316)		-0.9696** (0.0283)
Cumulative production		0.3582** (0.1318)	0.1915** (0.0484)		0.1981* (0.0842)	0.1854** (0.0478)
SSE	1.778	13.510	0.929	1.763	9.253	0.965
F-test	388.420**	14.560**	367.420**	211.710**	6.970*	199.970**
R ² adjusted	0.902	0.249	0.947	0.834	0.127	0.907
log likelihood	7.483	-35.776	20.448	7.657	-27.829	19.634
DW	2.433	2.103	2.353	2.414	2.040	2.341
Rho	0.863	0.362	0.793	0.856	0.162	0.833

Standard errors in parenthesis. * and ** denote statistical significance at the 5% and 1% level respectively.

The equations were estimated using maximum likelihood methods. As tests revealed the presence of autocorrelation, each equation was estimated assuming that the error term follows a first-order serial correlation. Parameter estimates of the cost function and learning curves of cataloguing the manuscripts and pages are presented in Table 2. The results from equation (10a) are presented under the column heading I, and the results from (10b) and (10c) under headings II and III respectively. Several regression statistics are also presented in the lower half of Table 2, namely; sums of squared residuals (SSE), F-test for the hypothesis that all slope variables equal zero, a measure of the goodness-of-

fit of each regression, R^2 , adjusted for the degrees of freedom, the value of the log likelihood function, Durbin-Watson test for first order autocorrelation and the rho-value of the associated autocorrelated component.

The b_y^* parameter is consistently estimated at just below minus one and is always highly significant. This implies that b_y is positive but very close to zero. Since it can be shown that estimates of returns-to-scale can be obtained by noting that the scale elasticity equals the inverse of b_y , it follows that the results indicate the presence of considerable increasing returns-to-scale. The parameter associated with cumulative production is positive, indicating that real average costs have been rising as accumulated production has increased.¹⁰ This is in direct contrast to results usually obtained from estimating learning curves, as average costs have generally declined in line with increased accumulated production volume.

The results show without doubt that the data at hand is inconsistent with a simple learning curve such as equation (10b). The parameter estimates of that equation are inferior to those obtained from estimating equations (10a) and (10c), and all other regression statistics favour equations where current output enters as a special variable.

The parameter estimates from the corresponding equations for digitisation of manuscripts and pages are presented in Table 5. As before, I find that b_y is close to zero, in some cases even negative, but the cumulative production variable is never significantly different from zero. The adjusted R^2 value associated with equation (10b) is poor in both cases, and the SSE value is also very high. It is therefore clear that the data at hand do not yield satisfactory statistical estimates of learning curves for the digitisation. The estimated equations for digitising pages also reveal that the parameter associated with current output is smaller than -1, indicating that the underlying cost elasticity is negative, and that costs can therefore be decreased through increased production. Since these results are contrary to conventional wisdom, we are left to conclude that neither estimates of learning curves nor simple cost functions yield amiable results for digitisation.

¹⁰ It is assumed here that the development of input prices can be approximated by a measure of the general price level, CPI. If, on the other hand, input prices have risen faster than CPI, real average costs will be overestimated, and

Table 5.

Parameter estimates of learning curves and cost functions. Digitisation of manuscripts and pages
The independent variable is real average cost. Number of observations is 34.

	Digitisation of manuscripts			Digitisation of pages		
	I	II	III	I	II	III
Constant	12.3053** (0.1966)	9.5700** (1.6174)	12.7662** (0.4923)	12.4020** (0.5044)	3.5222 (2.2342)	13.2537** (1.0335)
Current output	-0.9923** (0.0599)		-0.9934** (0.0603)	-1.0086** (0.0584)		-1.0077** (0.0598)
Cumulative production		-0.0403 (0.2814)	-0.0969 (0.0791)		0.0247 (0.1975)	-0.0771 (0.0767)
SSE	2.090	21.710	1.857	2.057	15.730	1.856
F-test	304.400**	0.370	162.440**	214.310**	0.110	112.600**
R ² adjusted	0.902	-0.120	0.910	0.866	-0.029	0.875
log likelihood	-0.828	-39.916	0.652	-0.560	-34.600	0.667
DW	1.692	2.255	1.655	1.677	2.185	1.642
Rho	0.577	0.622	0.524	0.581	0.363	0.530

Standard errors in parenthesis. * and ** denote statistical significance at the 5% and 1% level respectively.

The estimated b_y -parameter is in all cases, both for the cataloguing and digitising processes, found to be very close to zero, indicating substantial returns-to-scale. These results stem from the fact that production (cataloguing or digitising) in certain - and very few - months far outstripped production during other months. Although it is quite likely that some scale economies exist in both cataloguing and digitising, the size of these estimated scale characteristics is much larger than could reasonably have been expected. The estimates of the b_n -parameter are disappointing. The parameter is often not statistically significant from zero, and in the cases where it is significant the sign of the parameter is positive, contrary to what is expected. Thus, it is clear that the theory that average costs decrease as production accumulates does not hold for the cataloguing and digitisation undertaken at the National Library.

A few points can be raised that may shed light on these unorthodox results. As mentioned in Section 5 above, it was unclear at the beginning of the SagaNet project how the catalogues should be constructed. Consequently, much of the cataloguing undertaken in

the early days of the project had to be supplemented at later stages. Changes in personnel also meant that new employees had to be trained which slowed down work on cataloguing. It should also be borne in mind that the digital camera broke down in early 2000 and the amount of library holdings digitised diminished considerably in the months immediately before and after the breakdown occurred.

8. Costs and benefits

All cost-benefits study consists of adding together the relevant costs and benefits and then examining whether the benefits outweigh the costs or vice versa.¹¹ Among the problems encountered most often are those of defining which items to include in the study, and how to quantify them so that the value of each component can be measured in dollars.¹² In this study the relevant cost and benefit items are pointed out, but the information at hand does not allow us to convert all these costs and benefits into dollar terms. Data do, however, exist on various costs directly associated with the SagaNet project, as discussed in Section 6 above. In what follows we first discuss the various costs involved for current library users, and the effect we believe the project will have on these costs. Attention is then focused on the various benefits believed to result from the project. Finally, we analyse maintenance costs and costs associated with using the SagaNet sites. It should be noted that, in the following discussion, we focus primarily on users of the National Library of Iceland, since, as mentioned before, neither the Árni Magnússon Institute nor the FIC are open to the general public.

Opportunity and transport costs. A useful first observation is that costs will differ pending on how far away from the library the prospective users live. Users can therefore be grouped on the basis of their geographical location; close to the library, say, within a 100 km. radius from Reykjavik, elsewhere in Iceland, and in a foreign country.

Users living close to Reykjavik will usually not have to make any special arrangements to visit the library but can do so as they please. Costs include the opportunity cost of visiting

¹¹ See Mishan (1988). For cost-benefit studies and evaluations of digital libraries, see Roderick (1998) and Marchionini (2000). See also Amir et al. (1998) and Levine and McClain (1997).

¹² Saracevic (2000, p. 351) notes that “maybe evaluation of digital libraries is so complex that, even when desired, it cannot be accomplished with what we presently know about evaluation.”

the library, which equals the costs of foregone earnings from doing something different. This opportunity cost will, of course, include time spent travelling to and from the library. Needless to say, library guests can often choose at which hours they visit the library and may in some cases plan their visits at off-peak hours, when the traffic flows more freely. But others may have to travel at times when the traffic is heavier, and in so doing increase the costs each driver imposes on the others by using a specific road or street. These social costs will also include the wear and tear of the roads and possible pollution. In addition, allowance must be made for the effects increased traffic has on accident rates. Finally, I note that the private costs of transportation also includes payment for fuel, as well as other variable vehicle costs.

Users living elsewhere in Iceland can either request that the manuscripts be sent to their local archive, in which case the costs are calculated in a similar manner as in the first case, or they may decide to visit the library in person. This may involve considerable costs for users living far away from Reykjavik, especially those who must pay for transport by bus or plane as well as accommodations in the capital. Note also, that the opportunity cost for those individuals can be quite high, as they may find themselves with time on their hands when the library is closed.

As mentioned above, the Department will furnish those users who so desire with microfilms or photographs. This is an especially important option for prospective foreign users, who otherwise might have to travel to Iceland. It should be noted that, although the manuscripts in the Department are sometimes loaned to institutions or libraries outside Iceland, individuals cannot reserve the manuscripts in a manner analogous to Icelanders living outside the capital region. The opportunity cost of visiting the National Library can, of course, be quite high for foreigners who have to visit Iceland in order to gain access to the manuscripts. However, these individuals are usually professional academics who, more often than not, are visiting the Árne Magnússon Institute and frequently have the manuscripts transferred to that Institute. These individuals are usually able to keep their own office hours and can therefore work during evenings and weekends if they so desire. Thus they may be able to put most of the time spent in Iceland to good use.

In-house library costs for users Once in the library, patrons will not, in general, have to pay for access to the manuscripts. The National Library will also provide users with

microfilms or photographs of the manuscripts free of charge but those cover only a small part of the collection. Patrons must, however, pay for extra photographs.

Present demand. In Section 4 above, we noted that about 300 books are borrowed each year from the FIC. In the year 2000, about 1200 loans were registered at the Manuscript Department. However, only a small proportion of these loans, possibly 10%, involved manuscripts that will be included in the SagaNet project. The total number of registered loans at these two libraries could therefore amount to 450-500 each year. In addition, 43 guests visited the Árni Magnússon Institute in 2000.

Demand changes. As explained earlier, it is unlikely that the SagaNet project will diminish the interest of scholars, both Icelandic and foreign, in spending some time at the Árni Magnússon Institute. The effects of the SagaNet project on visits to the National Library and FIC are, however, uncertain. The images on the SagaNet sites will in many cases be perfect substitutes for the original material, and in these cases users will not have to visit the library in question. Since the variable Internet costs are usually lower than the costs associated with visiting the library in person, private – and social – savings can be expected. But it is also quite conceivable that visits to the websites will stimulate further interest in studying the manuscripts and other SagaNet material.

Computer technology changes. Based on recent technological developments, it is likely that Internet connections will become increasingly faster and the carrying capacity greater. Personal computers have also become more powerful, the processors quicker and the memory larger. In the future, it is therefore quite possible that higher-resolution digital images will be stored on the SagaNet sites, and that it may also become feasible to send these same images directly to individual Internet users. This development would therefore benefit the users substantially and might lessen the need for patrons to visit the libraries in person, thus reducing variable library costs.

Library costs. The effects of the project on library costs are also unclear but are projected to be of minor importance. Demand for research facilities at the Árni Magnússon Institute is assumed to remain unchanged, whereas, as explained above, interest in the Manuscript Department and FIC holdings could either increase or decrease. However, the number of registered loans in both these institutes is very low, and loan traffic would have to change dramatically to have a serious effect on costs in both places.

The conclusion that can be drawn from this discussion is that the SagaNet project is not assumed to affect the library demand for SagaNet holdings. Thus, direct library costs should not change much, nor are there expected to be significant changes in the private and social costs associated with visiting the libraries.

Non-pecuniary benefits to users. There are, however, at least three kind of non-pecuniary benefits that library patrons can be expected to gain from the project. First, good, computerised catalogues will exist of all the material included in the SagaNet. This will be of special value to patrons of the National Library, as the catalogues there were incomplete, while the old catalogues at FIC and ÁMI were much better. Second, patrons will now be able to obtain, for a fee, high-quality pictures of the manuscripts. Third, interested individuals will now be able to access the manuscripts and printed material on the Internet at all times instead of only during library hours. It is assumed here that patrons will be able to adapt to the new technology and learn to work with digital images on a computer screen instead of printed material and manuscripts. Older users may, though, may find it difficult to master the new skills required. Fourth, the availability of this material may stimulate research in other fields.

Library benefits. Needless to say, the libraries themselves also stand to gain considerably. First, better catalogues will be of tremendous use for the libraries, as well as for the patrons, not least for helping distant customers to locate material of interest. The libraries should therefore be able to provide better service. Second, the library will obtain excellent high-resolution digital images of the manuscripts, which can be held as backups, in case the originals are damaged or lost. Third, the images will be good substitutes for the original manuscripts, which should lead to more sparing use of the originals and limit wear and tear. The needs for out-of-library loans will be smaller, and insurance and transport costs will be lower.

National and global benefits. Finally, we can also observe some national, even global, benefits to be derived from the project. By throwing the doors wide open and making Icelandic medieval literature available on the Internet, the global community is challenged to drink from this cultural cup that has quenched the thirst of Icelanders and other Nordic nations for centuries. At this stage, it is impossible to know how the SagaNet project will be received, but hopes are high that it will generate increased

interest in Iceland literature and culture, as well as providing those already familiar with the texts with new and improved tools to study the Sagas. Preliminary figures indicate that a substantial number of Internet users are already aware of the SagaNet project. Thus, during the period 25th January - 17th June 2001, 262 guests from 18 countries visited the sites. Of these, 75 users had Icelandic email addresses, 52 addresses had in other Nordic countries, and 58 had email addresses in the US. Most of the visitors were professionals, or 164, university students numbered 52 and non-academics were 32. It is hoped that more Internet users will pay visits to the sites in the future, but the future demand is impossible to predict.¹³

Last but not least, the SagaNet project will be an important vehicle to introduce Iceland to foreigners, even those not very interest in literature. As such, the sites may stimulate tourism to the country and have other positive side effects.

Internet costs. There will, however, also be costs involved for users of the SagaNet. In order to take advantage of the site, users have to own or have access to a computer and be able to log on to the Internet. Costs to the user include various set-up costs, such as the necessary hardware and software and an Internet subscription, and payments for time spent on the Internet. Additional costs include various consumables, such as paper, ink and/or toner for the printer. In order to take advantage of the SagaNet sites, users only have to register but can otherwise access the catalogues and images free of charge. In the future, however, it is possible that only registered subscribers will be allowed on the sites.¹⁴ Such a change would, of course, raise total user costs.

Maintenance costs. Finally, it should also be noted that setting up the project and cataloguing and digitising the material does not tell the whole story. Indeed, the SagaNet, like any other digital library, will need to be constantly maintained. The ongoing costs include salaries, benefits and other labour costs, annual maintenance of the hardware and software, and replacement costs. It is likely that new and improved means of storing digital material will appear in the future, and that new investments will have to be made every 5-10 years. The Saganet will be a part of the Icelandic Digital National Library and

¹³ It is implicitly assumed here that increasing the amount of information on the Internet will improve the well-being of the world at large, but this has been debated. See Levy (2000).

¹⁴ A thoughtful analysis of site licensing is found in Kahin (1996).

those costs will be included there. These costs could, at least partially, be met by setting up a subscription system, but would otherwise have to be financed by other means.

The costs and benefits the SagaNet project can be expected to bring are summarised in Table 6. As has been stressed above, the monetary value of most of the items included in the table can not be estimated, given the limited information available.

Table 6.
Expected costs and benefits of the SagaNet project.

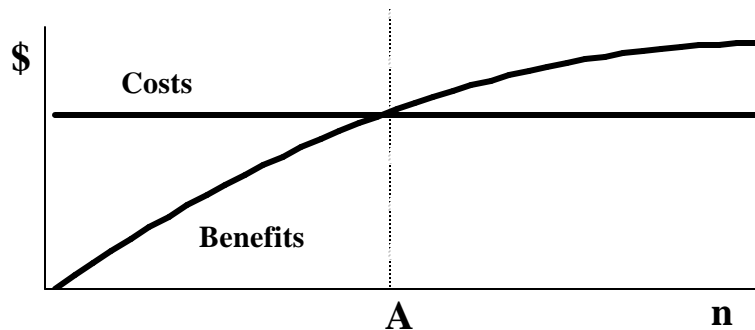
<i>Initial costs:</i>	
	Setting up the sites
 <i>Project lifetime costs and benefits:</i>	
<i>Costs:</i>	
	Library maintenance and variable costs
	User costs
 <i>Benefits:</i>	
Users	24 hours access
	Good catalogues
	High-quality images
	Stimulate interest in other fields
 Library	
	Good catalogues
	High-quality images
	Less wear and tear of manuscripts
	Lower transportation and insurance costs
	 Increased interest in Nordic culture and heritage
	Increased interest in Iceland

It is, however, possible to conduct a stylised cost-benefit analysis, as shown in Figure 7. Suppose the library costs associated with maintaining and improving the SagaNet sites are fixed, i.e. independent of the number of users. The assumption of fixed costs is only made for convenience and can be relaxed without affecting the analysis.

The total benefits enjoyed depend on the number of users and the value each user attaches to the SagaNet. The concave curve representing benefits in Figure 7 is drawn under the assumption that users value the SagaNet differently, which would seem to be a fairly logical assumption. Hence, the slope of the curve is greatest close to the origin, indicating

that the SagaNet will first attract those users that value the project highest and that subsequent users will value it less.¹⁵ At point A, costs and benefits of the project are equal, while the costs outweigh the benefits to the left of point A. To the right of point A, total benefits outstrip total costs. Note, that the set-up costs are not included in this analysis, but are regarded as sunk costs that will have no bearing on the costs and benefits derived from the project. Nevertheless, it would be desirable if the present value of the net benefits (total benefits minus costs) equalled or exceeded the present value of the set-up costs.

Figure 7.
Stylised cost-benefit analysis of the SagaNet project.



9. Conclusion

The SagaNet project consists of scanning, cataloguing and making accessible on the Internet Icelandic manuscripts and printed material on Icelandic and Germanic/Nordic literature housed at three locations: the National and University Library of Iceland, the Árni Magnússon Institute in Iceland and Cornell University's Fiske Icelandic Collection. The creation of this digital library will therefore allow users to browse through material that previously was dispersed on both sides of the Atlantic Ocean.

In all, about 350,000 pages were digitised, at the three institutions. In addition, 197,000 pages were catalogued at the National Library, and the catalogues at both FIC and AIM were updated and improved. The total cost for the SagaNet project amounted to \$1.3 million dollars.

¹⁵ The benefit curve would be a straight line with a positive slope if all users were assumed to value the

Average costs per catalogued and scanned manuscript at the National Library amounted to \$866.2 and \$225.5 respectively, while the corresponding costs for catalogued and scanned pages were \$2.4 and \$0.8 respectively. Statistical analysis showed considerable returns-to-scale, but the existence of a learning curve could not be confirmed.

The project is unlikely to have much impact on current library and user costs, both private and social, but in the future additional expenditures will be necessary to maintain the sites and adapt the digital library to the changing technical demands of tomorrow.

The project should, however, have some positive effects. Among the most important are the construction of improved, computerised catalogues and the creation of high-resolution digital images. In addition, the digital library will be open 24 hours a day. The service enjoyed by prospective users will therefore improve vastly. The digital images will also serve as backups to the original manuscripts and printed material, and will, in some cases at least, act as perfect substitutes for the originals. This should decrease the number of out-of-house manuscript loans, thus reducing transportation and insurance costs, as well as diminishing wear and tear on the manuscripts.

The SagaNet can also be expected to have some global effects. It will hopefully introduce new individuals to Icelandic Medieval literature and act as an important tool for those already familiar with the field. Finally, the sites should encourage interest in Iceland and Nordic culture in general, perhaps leading in due time to increased tourism in these parts of the world.

References

- Amir, Yair, Baruch Awerbuch and Ryan S. Borgstrom (1998): *A Cost-Benefit Framework for Online Management of a Metacomputing System*. Paper presented at the 1st International Conference on Information and Computation Economies (ICE-98), Charleston, October 1998.
- Berndt, Ernst R. (1991): *The Practice of Econometrics: Classic and Contemporary*. Reading, Massachusetts: Addison-Wesley.
- Chambers, Robert G. (1988): *Applied Production Analysis*. Cambridge: Cambridge University Press.
- Cornes, Richard (1992): *Duality and Modern Economics*. Cambridge: Cambridge University Press.
- Greenstein, Daniel (2000): "Digital Libraries and Their Challenges." *Library Trends*, Urbana, Fall, pp. 290-303.
- Kahin, Brian (1996): "Developing the Digital Library: Institutional, Legal and Policy Issues." In Teresa Harrison and Timothy Stephens (eds.): *Computer Networks and Scholarly Communications in the 21st Century University*. New York: SUNY Press.
- Levine, Larry and Betsy McClain (1997): *Cost Accounting a Network – A Case Study*. Paper presented at CAUSE97, Lake Buena Vista, December 1997.
- Marchionini, Gary (2000): "Evaluating Digital Libraries: A Longitudinal and Multifaceted View." *Library Trends*, Urbana, Fall, pp. 304-333.
- Mishan, E.J. (1988): *Cost-Benefit Analysis*. Fourth Edition. London: Unwin Hyman.
- Roderick, Elizabeth (1998): *More Than Just Pretty Pictures: A Cost/Benefit Analysis of Digital Library Holdings*. Paper presented at CAUSE98, Seattle, December 1998.
- Saracevic, Tefko (2000): "Digital Library Evaluation: Toward an Evolution of Concepts." *Library Trends*, Urbana, Fall, pp. 50-369.
- Varian, Hal R. (1992): *Microeconomic Analysis*. Third Edition. New York: W.W. Norton.