The commercialisation of bioinformatics and the threat of open-source software

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Abstract
This study investigates the commercialisation process of a select group of bioinformatics companies and the impact of open-source software. Using the research–development–application translation model provides a framework for managers as an iterative mechanism. A Value Creation Pipeline is then introduced with five phases of the commercialisation process that provide specific financial benchmarks that can guide the firm through to successful commercialisation. Using trend and financial ratio analyses relative to returns, profitability and liquidity, the study finds that the surge in open-source licenses between 2003 and 2005 limited the sales for some firms. As for the claim that open-source software negatively impacts the success of bioinformatics commercialisation, there was little evidence to suggest a direct cause-and-effect relationship. Losses in returns, profitability and liquidity were just as common before the rise of open source as after its emergence. When firms report an overall record over a nine-year period of poor return on investment, assets and equity, there is little to attract potential investors. The lesson that can be drawn is that the innovation process and financial tracking must be integrated to ensure efficient and profitable use of investor funds.
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INTRODUCTION

The commercialisation of technology remains an inexact science especially in the bioinformatics sector, and many investors doubt that the majority of technology companies can be profitable there. Once considered the premier investment in the late 1990s, the recent history of the sector shows the fallout from high-profile burnouts. To compound their challenges, bioinformatics firms were confronted with a new trend evident by 2002 and traceable to 1992, when Philip Green, a University of Washington biologist, wanted to decipher the human genome with a more accurate reading of DNA letters. At the time, he was using a Celera-made machine supplied by the bioinformatics company Applied Biosystems. Not satisfied with Applied Biosystems's software, Green developed his own software over the objections of the supplier who did not take preventive legal action. Today, Green's open-source software is considered the industry standard and its source code is freely available.[1]

Profitable rates of return usually depend on a significant competitive advantage. Some researchers questioned whether a company

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was likely to retain its competitive advantage and to profit from its software package if potential customers could obtain the software for free elsewhere, or if a competitor has free access to the complete source code of their package. Licensing agreements have been created that exclude competitors and protect a competitive advantage and, in the process, allow companies to make significant additional investment in the development of new software packages. On the other hand, supporters of open-source software claim it promotes more research since it allows the free exchange of accessible information that stimulates even more scientific research.

Issues

Two of the more critical issues in the successful commercialisation of bioinformatics technology arise from serious concerns related to the profitability of the sector and the potential negative impact of open-source software and on the value-added process of competing firms. Previous commercialisation research overlooks specific behaviour and few have used financial indicators to measure the successes associated with the commercialisation process. The purpose of this study is to characterise the commercialisation process from a new perspective, to analyse the commercialisation process financially, especially the recent impact of open-source software on a sample of bioinformatics firms, and to offer new insights for the successful commercialisation of future bioinformatics firms.

THE COMMERCIALISATION OF BIOINFORMATICS

The bioinformatics sector

The field of bioinformatics studies the use of computer software to handle biological information or the methods of computational molecular biology, which are used to characterise the molecular components of living things.[2] This evolving field also studies the uses of software to store, retrieve, analyse or simulate the composition or structure of bio-molecules, which include genetic materials such as nucleic acids, and the products of genes such as proteins. Others prefer to describe bioinformatics as the related fields of medical imaging, image analysis, genetic algorithms and neural network. The major research areas of bioinformatics include sequence analysis such as genomic annotation, computational evolutionary biology, measurement of biodiversity, gene expression analysis, regulation analysis, protein expression analysis, analysis of mutations in cancer, structural prediction, comparative genomics, modelling biological systems and high-throughput image analysis. Mathematical operations are often used in bioinformatics to extract useful information from 'noisy' data produced by high-throughput biological techniques and especially genomics. Computers are the primary tools to process and store data, to reconcile these data with other existing data sets and to build layers of data sets on top of data sets. The data sets provide critical inputs for computer-based researchers that wet biologists normally gather over extended time periods from their live, laboratory-based experiments. The value-added proposition of bioinformatics cannot be overstated here. Using computers and software rather than live lab-based experiments reduces substantially the high cost of laboratories. In the late 1990s, many investors saw this value proposition and the potential financial reward and fuelled the surge in formation of bioinformatics companies.

The rise of the open-source movement

The open-source movement is a by-product of the free software movement that advocates open-source software as an alternative method for free software. The movement was founded in 1998 most notably by John Hall, Larry Augustin, Eric S. Raymond and Bruce Perens, and coincided with the dot-com boom of 1998–2000. Linux grew at a strong pace along with other 'open-source–friendly' software platforms that became popular. In addition to Linux by Corel, the mainstream software industry started offering open-source software such as StarOffice by Sun Microsystems and OpenAFS by IBM.[3]

Open-source software means that the information in the form of a computer software program is made available to the general public, can be freely copied, distributed, modified and manufactured. According to the Open Source Initiative,[4] the software is considered open source as long as the distribution of the software complies with certain criteria, namely that redistribution is free, that the source code is included and that modifications and derived works are allowed and even encouraged.

For software to be truly open source, some proponents believe there should be

- no discrimination against persons, groups or fields of endeavour;
- distribution of the license should be free and must not be specific to a product;
- a license must not restrict other software and be technology-neutral.

The Linux system, an outstanding example of open-source software, is in widespread use and supported by many major hardware suppliers.[5]

Much of the existing work in bioinformatics software that is distributed under open-source licensing is based on these systems, languages and platforms such as Perl and Unix.[6]

Open-source initiatives have grown quickly and are very widespread.[4] Proponents believe open-source software is often more efficient, better designed and generally more reliable than equivalent commercial software. To many researchers, who were concerned that much of the important data might end up being locked inside proprietary corporate databases of the bioinformatics companies and access limited by the high potential fees, open-source licensing is a welcome development in the biotechnology field.[7] Open-source developers and proponents are often graduate students, post-doctoral researchers and teaching assistants who, in their attempt to explore and advance technology, share a widespread philosophical belief to share information freely and widely.

Inconsistent requirements to license open-source software have brought a complexity to the implementation of open source and especially the protection of intellectual property (IP).[8] As of May 2006, 58 different open-source licenses are endorsed by the Open Source Initiative, each of which has different terms and implications for the protection of IP rights and commercialisation. Different license agreements are used by many different entities that distribute open-source software. Some licenses require fees for use while others only allow the redistribution of the software by the software's author.[9]

The relationship between bioinformatics and open-source licensing

Recently, the use of open-source licensing in bioinformatics has accelerated. A celebrated example is found at the website www.bioinformatics.org. According to Bioinformatics Organization, Inc., a group that serves the scientific and educational needs of bioinformatics practitioners, open source promotes open access to the materials and methods required for, and derived from, research, development and education. It is also well known for its emphasis on open access to biological information as well as on free and open-source software.

After the dot-com decline of 2000, the cost-cutting climate in business encouraged the open-source movement to grow faster. Bioinformatics.org, incorporated in 2003, had more than 14,000 members and over 200 projects by the end of 2005. In 2005, the major Open Source Bioinformatics projects were Bioperl, Ensembl, Biojava, Biopython, O|B|F, Omnigene, Bioruby, 'Glue' projects, DAS, bioinformatics.org (Jeff Bizzaro), which is SourceForge for Bioinformatics, EMBOSS, BioFortran, BioLisp, BioSVG and many other smaller projects. They actively engaged in the sharing and swapping of bioinformatics code and expertise over the internet so as to build an 'ideal society' of researchers, a place where professionals access programs and take part in ongoing development projects free of charge. As access to free software increased, many opponents believed that the movement posed a threat not only to the shaky profitability of bioinformatics companies but also to the future of the commercialisation process in the sector.

A COMMERCIALISATION MODEL

The research–development–application translation process

Bioinformatics as a technology sector experiences the same fundamental challenges of successful development that all bioenterprises face, that is, to facilitate the process where new knowledge is transformed into a practical, commercially viable application. Some researchers[10] have characterised the process as the research–development–application (R–D–A) translation process (Figure 1). The characterisation provides a useful conceptual framework for financial analysis of the study when it identifies discrete phases. Once the phases are identified, the financial indicators can focus on specific behaviours by the financial management. Referring to Figure 1, the process of responding to market opportunities and needs at the top of the chart represents an iterative process where R–D–A is continuously repeated until the maximum commercial, clinical and social uses are obtained. *Research* is defined as the space where academic and research institutions develop new concepts and knowledge in the sector. The analogy of a large holding tank is depicted to represent the fast pace of technological innovation currently at work in the markets. *Development* translates the concepts and insights into a practical application, which may or may not be ready for the marketplace where distribution and sales take place. It is important to note the small channel that translates research concepts through the *Development* pipeline and into the much smaller *Application* tank. The process of translating concepts from the larger *Research* tank into high-value product, services, and technologies has not been very efficient, thus the smaller pipeline and much smaller *Application* tank.

The Value Creation Pipeline

Building on the R–D–A translation process, the Value Creation Pipeline (Figure 2) emphasises five discrete phases related to the innovation process. Moving from left to right as *Research* moves into *Development* and *Application*, the value proposition increases as execution risk decreases. The length of time for each phase will vary according to the technology sector. For example, the Productisation phase for bioinformatics software may last as little as three to six months whereas the same phase for a new drug may last for many years given the pre- and post-trial requirements. The Concept and Technology Validation phases refer to the creative ideas that must be demonstrated as technically feasible and workable. In the Productisation Phase, the validated concepts are converted into commercially ready products. Perhaps the most critical phases for successful commercialisation are the Business Case Validation and the Market Entry and Growth. In the Business Case Validation phase, it is demonstrated that a market exists for the product. In particular, this may mean determining whether to use distributors, network marketing or to sell over the internet. In the Market Entry and Growth

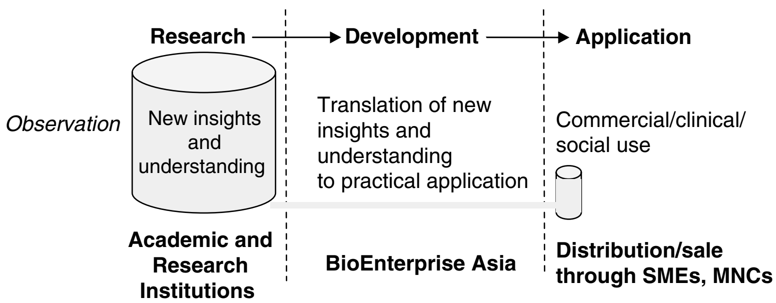

Figure 1: R–D–A translation process
Source: Shahi[10] (Reproduced with permission from Gurinder Shahi and BioEnterprise Asia)

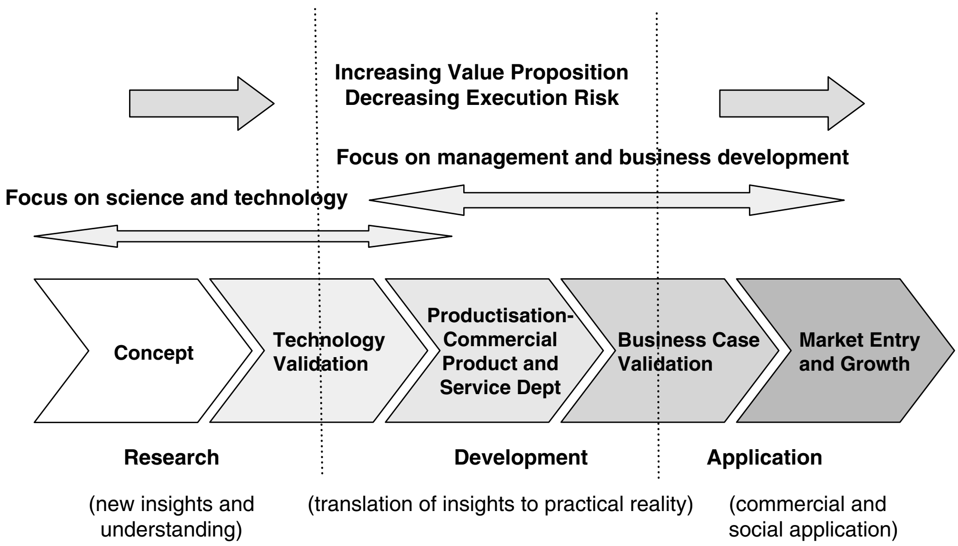

Figure 2: The Value Creation Pipeline
Source: Shahi[10] (Reproduced with permission from Gurinder Shahi and BioEnterprise Asia)

Phase, the product is brought to the market, where, if successful, it will generate, maintain and grow as a profitable enterprise. The second half of the process from productisation through business case validation to market entry and development requires strong management and business development skills. It is at these points that the study will focus its financial spotlight.

METHODOLOGY OF THE ANALYSIS

The sample

The study analysed the nine-year time period from 1997 to 2005 that captures the surge in financing new ventures in the late 1990s. The time period was also chosen to identify the financial sensitivity of four bioinformatics companies and the relationship, if any, to the accelerating popularity of open-source licensing during the period 2002–2005. In addition, the four firms selected are publicly traded and file regular disclosures as required by the Securities and Exchange Commission, which allows ready access to financial data. The four firms were Accelrys Inc (ACCL), Datatrak (DATA), Tripos, Inc. (TRPS) and Gene Logic (GLGC), all of which were founded and went public between 1994 and 1997. Evidence from the financial statements indicated that initial capital came from private equity investors. The lines of business for each company were consistent with a bioinformatics business model that provides software and other related services for computation, simulation and the mining of scientific data used by biologists, chemists and life sciences researchers.

A two-part analysis was employed. Part One presents a financial overview of the four firms during the sample period. Revenues, net income and research and development spending were investigated. Part Two employed a financial ratio analysis that indicated liquidity, profitability and return on investment (ROI). In this section, the analysis investigates how capably and efficiently the financial management in the firms used the funds supplied by investors. It also asks the questions how successful the management of the firms were in their efforts to generate, sustain and grow the company's profits. A third area of analysis takes the perspective of the potential investor, creditor or supplier to the bioinformatics sector when it asks the question how well did the management meet its current financial obligations and build a margin of safety to protect itself from financial distress.

Part One – Financial overview

The study examined company performance during the sample period 1997–2005 to investigate trends and their directions using the income statements as well as the balance sheets, and specifically, the following accounts: revenues, net income and research and development expenses.

Revenues

Sales of software, fee-for-service research and licensing of technology were the major sources of revenue for all of the companies investigated. Results from Table 1 and Figure 3 show a rise in total sales of the four firms from 1997 to 2003 but a steady decline for the following two years. The corporate results show a slower growth trend for all the sample firms after 2003, the time period when the rise of open-source software increased significantly. For seven of the nine years, ACCL was the largest bioinformatics company by revenues in the sample. During the 1997–2000 period, the company experienced strong annual growth in sales revenues. Although data were not available for 1997, the results show that the initial annual revenues of $92m in 1998 grew to an historic high of $122.4m by 2002, but growth in the years after 2002 showed significant slowing. ACCL's revenue growth slowed to 2.4 per cent in 2001 and even further to 1.7 per cent in 2002. ACCL reported a loss in revenues of 7.5 per cent in 2003.

Tripos, the second largest firm in the sample by revenues, recorded annual revenue losses to start and end the sample period. In between 1997 and 2005, it reported growth annually starting at $25.6m in 1998 to a high of $64.8m in 2004. Its growth rate peaked in 2001 at 69.1 per cent, but decreased significantly in 2002 to just 4.1 per cent as the usage, again, of open-source software increased. Although it rebounded in 2004

Table 1: Bioinformatics company revenues 1997–2005 (millions)

	1997	1998	1999	2000	2001	2002	2003	2004	2005
Accelrys	NA	92.2	104	119.4	122.3	124.4	115.1	79.5	69.6
% change		—	12.7	14.8	2.4	1.7	−7.5	−30.9	−12.5
Tripos	30.2	25.6	27.2	29	49.1	51.1	54.1	64.8	55.4
% change		−15.3	6.6	6.5	69.1	4.1	6	19.6	−14.4
Datatrak	17.3	13.2	5.8	2	2.2	4.7	7.1	11.3	15.7
% change		−23.2	−56.1	−65.7	12.6	110.2	49.4	60.3	39.2
Gene Logic	2	13.2	19.2	26.9	43.3	54.8	69.5	75.9	79.4
% change		544.6	45.5	40	61.2	26.6	26.7	9.2	4.5
Total sales	49.5	144.2	156.2	177.3	216.9	235	245.8	231.5	220.1

Source: www.hoovers.com

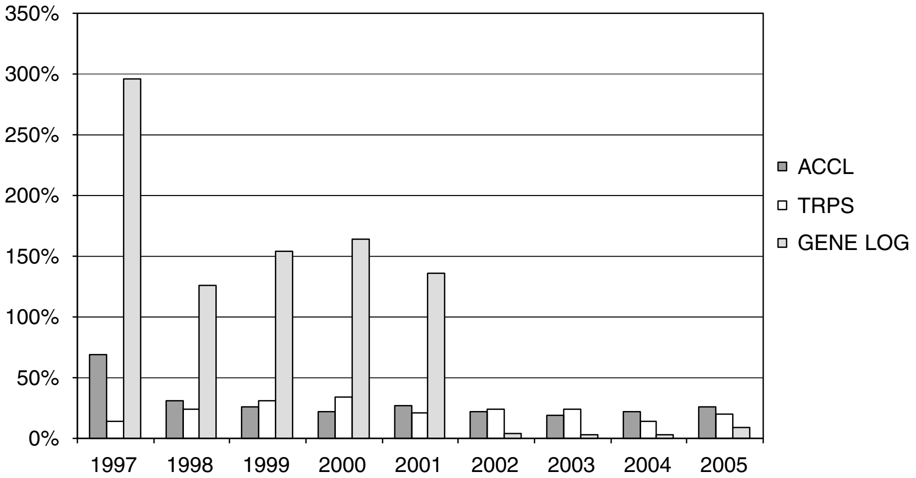

Figure 3: R&D expense as a percentage of sales (1997–2005)
Source: Company annual reports

with a growth of 19.6 per cent, by 2005 it reported its first loss in more than eight years with a significant loss in revenues of 14.4 per cent over 2004.

Datatrak (DATA) ranked third in size by revenues. In 1997, Datatrak reported annual revenues of $17.3m but declined substantially to 2.2 by 2001, the lowest year in the sample for this firm. Unlike Accelerys or Tripos, it ended the sample period in 2005 reporting revenues at a near-record high of $15.7m. On the other hand, the firm slipped to the lowest in revenue size for all firms in the sample. Unlike the other firms, Datatrak experienced annual losses in revenues from 1997 to 2000. By 2002, revenue growth grew to 110 per cent, then declined every year thereafter to 39.2 per cent in 2005.

Gene Logic, the smallest firm of the sample in 1997, ended the period as the largest by revenues, growing from $2.0m to $79.4m in 2005. It reported the lowest revenues of $2.0m for all firms in 1997 but jumped to $13.2m in 1998. By 2001, it experienced revenues of $43.3m. Although it experienced a strong growth in revenues during the time period, the revenue growth slowed considerably after 2001. Prior to 2001, its annual average revenue growth was 173 per cent. After 2001, growth averaged a significantly lower 16.8 per cent annually with the 2004–2005 change representing its weakest annual rate of 4.5 per cent.

Net income

Table 2 shows that all of the sample firms exhibited the negative early cash flows characteristic of the biotech sector for start-ups. Although Accelrys showed strong sales growth in the earlier years of the sample, it only had positive net income during 1999–2000, and consistently recorded losses every year after 2000. More interesting is the significant volatility of its net income with changes ranging from a positive 70 per cent between 2002 and 2003 and to a negative 808.6 per cent between 2003 and 2004.

Tripos managed to begin the sample period (Figure 4) with a positive net income in 1997 and 1998, then recording consecutive losses of $2.3m and $2.1m for 1999 and 2000. From 2001 to 2004 its net income was annually positive, but it ended the sample with a loss of $4.3m for 2005. Of the four firms in the study, Tripos showed the greatest annual volatility in net income changes ranging from a positive gain of 2,615 per cent between the years 1997 and 1998 to a negative change of 2,250 per cent between 2004 and 2005.

Datatrak's annual net income record showed more years of negative rather than positive results. With profits of $9.8m in net income for 1999, it finished the sample period with two consecutive years of positive net income of $8m in 2004 and $2.5m in 2005. Volatility in annual net income changes was not as severe as Accelrys and Tripos, although there were periods of significant change ranging from a negative 154 per cent change to a positive 213 per cent in 2000 and 2005, respectively.

Gene Logic recorded consistent annual losses from 1997 to 2005. The greatest losses were reported in 1998 with $44.9m and in 2005 with $48.3m. The closest it came to breakeven was the first year of the sample in 1997 with a loss of $7.2m. Again, this company experienced extremes in income volatility consistent and characteristic of all firms in the sample ranging from a positive

Table 2: Bioinformatics company net income, 1997–2005 (millions)

	1997	1998	1999	2000	2001	2002	2003	2004	2005
Accelrys	−6.7	−10.2	3.8	1.2	−14.3	−11.6	−3.5	−24.8	−25.2
% change		−52.2	368	−68.4	−129.2	18.9	70	−808.6	−1.6
Tripos	2.6	70.6	−2.3	−2.1	5.9	0.9	2.1	0.2	−4.3
% change		2615.4	−103.2	8.7	381.0	−87.7	133.3	−90.4	−2250.0
Datatrak	−7.4	−14.1	9.8	−5.3	−7.4	−6.4	−1	0.8	2.5
% change		−90.54	169.5	−154.0	−39.6	13.5	84.3	180.0	212.5
Gene Logic	−7.2	−44.9	−20.6	−24	−33.2	−24.1	−24.8	−28.5	−48.3
% change		−523.6	54.1	−19.4	−38.3	27.4	−2.9	−14.9	−69.4

Source: www.hoovers.com

gain of 54 per cent between 1998 and 1999 and to a 524 per cent negative change between 1997 and 1998.

Research and development

Of the firms sampled, Gene Logic had the most stable growth in revenue. At the same time, the percentage of R&D expense to revenue from 1997 to 2001, respectively, was 296, 126, 154, 164 and 136 per cent. Gene Logic was substantially higher than the other three companies (Figure 5). As the study mentioned earlier, bioinformatics companies usually depend on the significant competitive advantage to generate profit. The future growth of bioinformatics companies is driven largely by continuous investing in research and development.

Part Two – Financial ratio analysis

In this section, analysis focuses more on individual firms in the sample and, specifically, how well the financial management of the firms handled the funds they were provided by investors; how well were they able to generate, sustain and grow the company's profits, if any, they created; and finally, how well did the management meet current obligations.

Management's ability to provide an adequate return

The first part of the analysis examined how well the management of the firm was providing a good return on the capital provided by the investors. Return on assets

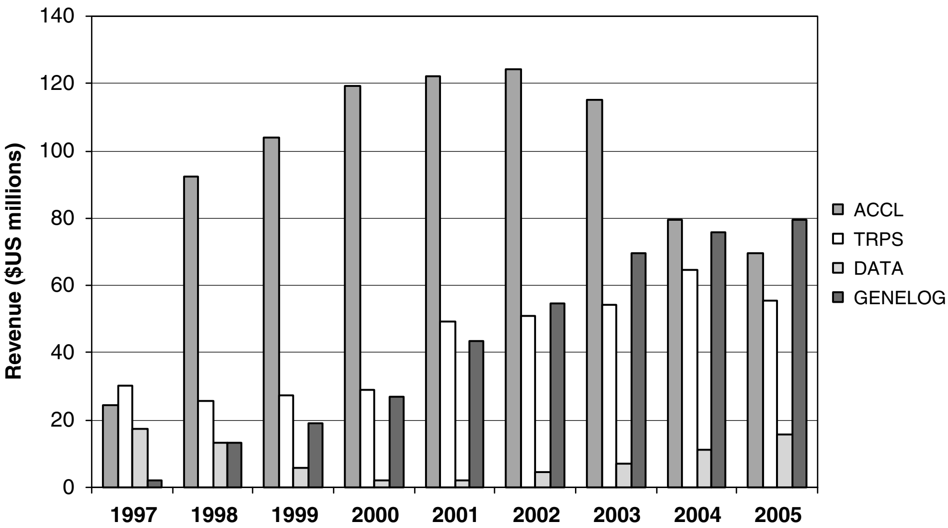

Figure 4: Company revenue (1997–2005)
Source: Company annual reports

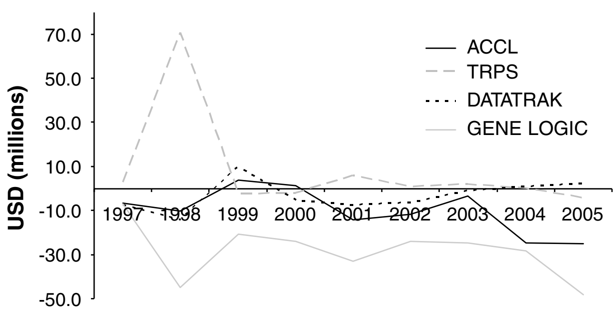

Figure 5: Bioinformatics company net income (1997–2005)
Source: Company annual reports

(ROA) measures the management's ability and efficiency in using the firm's assets to generate profits. It is measured by taking net income and dividing it by total assets and indicating the total return that accrues to all providers of capital (debt and equity). Return on equity (ROE) measures the management's ability and efficiency to use the capital supplied by investors in exchange for equity in the firm.

Results from Table 3 reflect the capital structures of the sample firms and the individual firm's ability and efficiency in using funds supplied by investors to generate positive returns. In general, the sample firms returned positive results in 11 out of 35 reporting years, a 31.4 per cent record for both ROA and ROE. Referring to the results for ROA, the indicators show how the management used all investor funds. Tripos showed positive return of assets of 7.91 in 1997 while the remaining sample firms showed negative values that same year. Datatrak started the sample period with the lowest ROA of negative 15.28. Although its results during the period were the most volatile, Datatrak was the only firm to post a positive ROA of 15.76 by 2005. Gene Logic was the lowest that year with a negative 30.05. With respect to return on stockholder-supplied capital ROE, similar negative results prevailed over the sample period again when 31.4 per cent of the time showed positive results but ROE levels were higher indicating a more efficient use of stockholder supplied funds by the management. Tripos was the only firm in 1997 to return a positive result of 14.15 but ended the sample period with a negative 14.53. On the other hand, Datatrak returned a negative 17.43 in 1997 but finished with a positive 18.53 in 2005, the only firm in the sample to have a successful return that year.

Profitability of the firm

The second part of the analysis investigates if the profits are sufficiently relative to the assets being invested or, simply, what is the rate of return the management is earning on the firm's assets. Table 4 presents several indicators that measure profits. Operating ROI indicates the level of operating profits relative to the assets and compares the profitability of the firm before the costs of the company's financing policies have been deducted. Next, operating income ROI was separated into the operating profit margin, a critical ratio in understanding the company's operations. It is also important to know what drives this ratio. Operating income is calculated by taking total sales deducting cost of goods sold, general and administrative expenses and marketing expenses, then dividing the result by total sales. Because total sales equals the number of units sold times the sales price per unit, and the cost of goods sold equals the number of units sold times the cost of goods sold per unit, we conclude that the driving forces of the operating profit margin are the number of units of product sold, the average selling price for each product unit, the cost of manufacturing the firm's product, the ability to control general and administrative expenses and the ability to

Table 3: Return management

	1997	1998	1999	2000	2001	2002	2003	2004	2005
Return on assets									
Accelrys	−6.98	−7.95	2.99	0.41	−5.45	−4.84	−1.46		−14.98
Datatrak	−15.28	−41.97	49.89	−36.47	−96.34	−120.45	−16.44	6.84	15.76
Tripos	7.91	0.19	−5.5	−3.59	8.71	1.27	2.93	0.32	−6.42
Gene Logic	−13.33	−80.76	−50.02	−7.84	−12.91	−10.57	−10.89	−13.77	−30.05
Return on equity									
Accelrys	−9.48	−14.07	4.79	0.56	−7.45	−6.34	−1.91		−25.66
Datatrak	−17.43	−49.85	53.09	−40.32	−127.79	−197.81	−22.79	8.08	18.53
Tripos	14.15	0.37	−13.02	−8.57	18.56	2.15	7.78	0.83	−14.53
Gene Logic	−15.62	−108.68	−89.26	−8.95	−14.68	−11.76	−12.41	−16.5	−38.69

Source: Company annual reports

Table 4: Profitability ratios

	1997	1998	1999	2000	2001	2002	2003	2004	2005
Return on investment									
ACCL	−459.52	−562.55	1,457.68	1,075.22	−29,200	−78,307.14	−111,850		−1,287,150
DATA	−14.97	−28.16	20.11	−10.49	−14.51	−11.83	−1.84	1.36	2.19
TRPS	115.77	7.44	−12.58	−449.43	259.26	20.24	65.16	122.24	−63.93
GENE LOG	−621.82	−1,095.77	−624.3	−1,258.30	−5,745.95	−2,299.49	−2,592.06	−4,062.30	−9,622.31
Operating margin (%)									
ACCL	−44.22	−14.59	0.14	−5.67	−16.31	−11.96	−4.97		−37.86
DATA	−53.84	−116.91	−79.55	−310.76	−342.6	−136.89	−15	7	7.45
TRPS	11.17	−5.06	−11.74	−8.56	9.71	−5.82	−10.06	3.71	−7.24
GENE LOG		−382.93	−109.81	−135.49	−84.35	−45.93	−29.11	−39.02	−64.28

Source: Company annual reports

Table 5: Liquidity ratios

	1997	1998	1999	2000	2001	2002	2003	2004	2005
Current ratio									
ACCL	3.37	2.1	2.39	3.0	3.04	3.5	3.51		1.53
DATA	6.53	5.62	15.42	9.43	3.5	1.71	2.95	5.7	5.48
TRPS	1.91	1.98	1.52	1.79	2.48	2.43	1.02	0.95	0.9
GENE LOG	7.49	3.68	1.37	7.53	8.47	9.23	5.94	4.95	3.09
Quick ratio									
ACCL	3.28	2.0	2.26	2.9	2.93	3.4	3.41		1.42
DATA	6.44	5.57	15.2	9.28	3.32	1.64	2.86	5.44	5.19
TRPS	1.81	1.58	1.28	1.52	2.19	1.98	0.55	0.49	0.58
GENE LOG	7.28	3.51	1.11	7.18	7.99	8.65	5.57	4.7	2.89

Source: Company annual reports

control the marketing and distribution costs of the firm.

In general, the results of the ratio analysis show the sample firms were most often (82.4 per cent) unable to generate, sustain and grow profits. The ROI levels for Tripos started the sample period in the strongest position at 115.77, but by the end of 2005, Gene Logic, the most volatile firm in profitability, recorded a negative ROI of 9,622.31. Although it started the sample with a negative value of 14.97, Datatrak was the most profitable firm by the year 2005 with an ROI of 2.19. As for Operating Margins, Tripos again starts the sample period with the strongest at 11.17 per cent but finishes the period with a negative 7.24 per cent. Datatrak begins the period with a negative 53.84 per cent and finishes with the only positive result of the sample firms at 7.45 per cent.

Liquidity of the firm

The liquidity of the firm can be defined as its ability to meet maturing debt obligations. In other words, liquidity indicates whether the firm has the resources to pay the debts owed to creditors when they are due. The analysis compares cash and the assets that should be converted into cash within the year with the debt (liabilities) that is due and payable within the year. Referring to Liquidity Indicators in Table 5, the current ratio is computed by the division of current assets by current liabilities. Given the conventional wisdom, firms should maintain about $2 in current assets for every $1 in current debt. The more restrictive measure of liquidity, the quick ratio, excludes inventories (the least liquid of the current assets) from the numerator, that is, current assets, cash and accounts receivable. Results from the quick ratio indicate the fastest a firm can create liquidity. Although cash reserves

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available play an important role, the ability of the firm to meet its current obligations is critical to successful commercialisation.

Referring to Table 5, all indicators for the end of the period 2005 were lower than the starting values in 1997. The results show the current ratio indicates levels at or above the 2.0 level for all firms in 1997. Over time, the weakest starter, Tripos, posted the worst performance of the sample firms and ended in 2005 with the lowest level of 0.9. The strongest finisher, Datatrak, posted the highest level in 1999 at 15.42 but finished in 2005 at a healthy 5.48. Gene Logic was second in liquidity levels at 3.07. Accelrys finished the period at a sub-part 1.53. Results for the quick ratio were similar to the current ratio with Tripos in the weakest finishing position (0.58) and Datatrak in the strongest position (5.19) in converting assets into cash and providing a margin of protection against financial distress.

Summary of results

Results from the nine-year overview present a very mixed picture. Although sales and the demand for the services of the bioinformatics firms continued throughout the survey period, there were significantly lower levels after 2002 as the rise of major open-source inititatives occurred. Even with higher research and development funding each year, net income losses persisted and affected every firm surveyed.

Overall, the results of the financial ratio analysis show, as was evident in the majority of negative returns on assets as well as on equity, that the funds supplied by investors were underutilised by the management of the firms. Only Datatrak ended the sample period efficiently utilising investor funds. A summary of the profitability ratios indicates that most often firms were unable to generate, sustain and grow the company's profits even during the years from 1997 to 2003 when sales grew steadily for most of the sample firms. Liquidity measures presented a picture of effective debt management. When the value of two was used as the benchmark, most often the firms sampled were able to easily convert assets into cash to meet their debt obligations.

CONCLUSION

Datatrak emerges as the best example of successful commercialisation of the four sampled firms. It appears to have effectively converted the growing demand for bioinformatics services into final sales over the last part of the sample period as evidenced by its positive results in the ratio analysis. Although the company's returns on assets and equity have a volatile record, the growth in its operating margins and liquidity makes it attractive to potential suppliers, creditors and investors. The company's results appear to confirm a growing market for bioinformatics services, especially for the types of products supplied by Datatrak.

As for the claim that open-source software negatively impacts the success of bioinformatics commercialisation, there was little compelling evidence to suggest a direct cause-and-effect relationship given the analysis in the study. The only evidence that offers some indication of a negative impact is the decrease in sales at Accelrys and Tripos following the year 2003 when an open source was experiencing a surge in usage. Nevertheless, losses in returns, profitability and liquidity were just as common before the rise of open source as after its emergence for all the sampled firms.

The results of the analysis are important for the continued success of the bioinformatics sector as well as for bio-business in general. The size of the time window available to capture the value of and advantage from technology is rapidly shrinking. This study provides the management with specific indicators or tools as they guide the firm through the successful commercialisation process. The R–D–A translation model provides managers with a framework in which to use the tools to succeed in all corporate departments. The five phases of the Value Creation Pipeline can act as specific benchmarks, especially on when to use the ratios during commercialisation. The benchmarks can guide new product development and innovations through the iterative innovation process that creates a continuous cycle of research, development, application and successful market entry and growth. If any lesson can be drawn from the firms sampled, it is that the innovation process and financial tracking must be closely integrated to ensure efficient and profitable use of investor funds.

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