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COST ACCOUNTING AT KESWICK, ENGLAND, c. 1598-1615: THE GERMAN CONNECTION

Abstract: The growing literature on the history of cost and management accounting has left virtually unexplored the developments prior to the British industrial revolution. Recently the business notebooks of Daniel Hechstetter, the German manager of an English copper works from 1597 to 1633, have been transcribed and published, making available what is probably the most detailed set of business records for a British-based industrial enterprise in this period. This paper examines Hechstetter's background and role at Keswick, and translates a sample of the calculations into modern English. These calculations show that a number of modern cost accounting concepts and procedures were in use by c. 1600. The significance of this in relation to our understanding of the development of cost and management accounting is assessed, and it is shown that there is a strong case for claiming that German enterpreneurs involved in this enterprise were responsible for introducing a range of cost accounting techniques to Britain.

It is evident from the growing number of published works on the subject that accounting and business historians are showing renewed interest in the origins of cost and management accounting. Furthermore, the findings of these studies are altering our understanding of the development of accounting procedures. For instance, until recently it was widely held that little or no progress was made in cost and management accounting in British industry before the end of the nineteenth century [e.g., E. Jones, 1981, pp. 111-16]. A growing body of evidence shows this view to be mistaken, and it is now accepted that a number of firms employed relatively sophisticated cost

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accounting systems by the late eighteenth century [Mepham, 1988, Edwards, 1989, Fleischman and Parker, Edwards and Newell]. Little, however, has been added to the understanding of the development of cost and management accounting before this period. This is in part due to the scarcity of early business records, but it is also due to the fact that recent literature has tended to focus upon the late eighteenth and nineteenth centuries, covering the span of the industrial revolution and its aftermath — a period when evidence for the emergence of new accounting procedures in response to changes in organization, scale and complexity of industrial activity might be expected to be found.

A notable exception is the study by Haydn Jones of accounting practices in Welsh industry and landed estates. Jones notes that the records of the Mines Royal Co.'s copper smelting works in Neath at the end of the sixteenth century display a "concern with output, cost and profitability", although he states that the earliest Welsh industrial accounting records suitable for analysis date from about one hundred years later [1985, pp. 7-8].

The Mines Royal Co.'s activities were not confined to south Wales, and it was noted some time ago that cost accounting was employed at the company's copper and silver works at Keswick in Cumberland [Donald, 1955, pp. 221-30], where Ulrich Fross, the manager at the Neath works, had been previously employed [Rees, 1968, Vol. 2, p. 431ff]. More recently, the business notebooks of the younger Daniel Hechstetter, a manager of the Keswick works from 1597 to 1633, have been transcribed and published [Hammersley, 1988], making readily available what is probably the most detailed set of business records for a British-based industrial enterprise in this period. These records are of particular interest to accounting historians because of the detail of the accounts and because they display a remarkable degree of cost-consciousness on the part of Hechstetter, who undertook calculations to assess the efficiency, profitability and future prospects of the enterprise.

The objectives of this paper are twofold. First, it draws attention to a range of calculations which add significantly to our knowledge of the early development of cost and management accounting. Second, it suggests that the accounting techniques employed were imported from Germany where they were already in use in a similiar industrial setting. After an historical introduction to the Keswick works and the role of Daniel Hechstetter, a sample of the calculations is reproduced, having

been translated from the original into modern English. The importance of these calculations in the understanding of the development of cost and management accounting is then examined.

THE HECHSTETTERS AND KESWICK

Daniel Hechstetter the younger was born in Augsburg, Germany, in 1562.[1] His father, Daniel Hechstetter senior, was a mining engineer and manager who had trained at the copper and silver mines in the Rauris Valley in the eastern Tyrol. His paternal grandfather, Joachim Hechstetter, had continued the family's merchant business in Augsburg and had some, though probably rather limited, involvement in mining.

Both Joachim and Daniel senior had interests in British mining. Joachim visited Britain in the 1520s when commissioned by Henry VIII to investigate gold, copper and lead resources in the British Isles [Rees, 1968, Vol. 1, p. 137]. It would appear that nothing came of this exercise. Daniel senior came to Britain in 1563 at the behest of Queen Elizabeth I as manager of a mining venture financed by the Augsburg merchant house of Haug, Langnauer & Co. Having been granted a prospector's warrant to search and work ores in Devon, Cornwall, Lancashire and Cumberland, Daniel senior and his associates decided to establish mines and smelting works at Keswick, Cumberland, of which Daniel senior became manager. From this mining venture was formed the Mines Royal Co. (well-known to historians for being one of the first two chartered manufacturing companies established in Britain).[2]

The younger Daniel probably spent his early childhood in Augsburg and came, with the rest of his family, to join his father in Keswick in 1571, when he was nine years of age. It is most likely that he was trained in mining and metallurgy at Keswick, partly by his father, but mostly by his older brother Emanuel, who was also involved in what was to develop into the family business.

In 1580, Daniel senior and Thomas Smith leased the Keswick mines and works from the Mines Royal Co., and these remained under the control of the Hechstetter family until 1633.

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[1]The historical details in this section have been obtained from the following sources: Colingwood, 1910, Donald, 1955, Hammersley, 1973 and 1988, and Rees, 1968.

[2]The other being the Co. of Mineral and Battery Works. See Scott, 1912, Vol. 1, p. 40ff.

Smith died in 1591 and was, for a time, succeeded by his son John. Daniel senior died in 1581 and was succeeded in the business by Emanuel and his son-in-law Mark Steinberger. When Steinberger died in 1597, he was replaced by Daniel junior. The lease of the works was surrendered in the same year, but the Hechstetter brothers continued to manage operations on behalf of the Mines Royal Co. until 1603, when they obtained a new lease on more favorable terms. Emanuel died in 1614 and was replaced by his son Joseph, while Daniel continued as manager at Keswick until he retired in 1633 at the age of seventy-one. The history of the Keswick works is uncertain after this date, but it would appear that they were run by a Thomas Whitmore sometime after 1633 until about 1636 and were closed in about 1640.

Throughout its history, the Keswick industry was never highly profitable. Silver was not found in the quantities hoped for and the company therefore relied upon the manufacture of copper for its main source of revenue. The combination of the high costs of mining and smelting in this remote and hilly location and the low price of copper throughout this period ensured that even in the early seventeenth century, when the enterprise was at its most successful, it was never more than moderately profitable.

Several studies of cost accounting have shown how the cost-consciousness of industrialists was heightened at times of low profitability [Burley, 1958, p. 58; McKendrick, 1970, p. 48]. It is not surprising, therefore, to find that the younger Daniel Hechstetter displayed a keen interest in costs throughout his period of management, given that his company was always operating on the margins of profitability. Neither is it surprising to find early use of cost accounting in this industry. A principal factor which is widely acknowledged as having influenced the development of costing in the late eighteenth and nineteenth centuries was the changing structure of industrial activity [e.g., Garner, 1954; Johnson, 1981]. Recent research has shown that smelting works and mines provided earlier examples of the types of centralized production units where cost accounting was likely to develop [Edwards, 1989, pp. 306-8]. Further support for this view is provided by evidence from the copper and iron industries which shows that smelters were particularly cost-conscious given the opportunities for incurring excessive costs through the inefficient use of resources in the smelting process [Edwards and Newell].

The costing techniques relevant to mining and smelting no

doubt required familiarity with the nature of the business activities and the response of costs to changes in activity, but they were relatively unsophisticated and could be worked out by a literate businessman with a degree of common sense. This should be noted, since there is no evidence to suggest that the younger Daniel Hechstetter was a particularly innovative businessman, metallurgist or accountant. It would appear, however, that he was a careful manager who was well-trained, technically competent and aware of the necessity to control costs if his business was to remain profitable. His business skills were almost certainly inherited from his father, Daniel senior, though perhaps passed on indirectly through training from his brother Emanuel.

By all accounts, Daniel senior was an astute businessman, and it was he who had masterminded the development of the Keswick works at a time when the company had faced severe financial difficulties. It was almost certainly the older Daniel and his fellow German workers who introduced cost accounting at the Keswick works. This is supported by the similarity of an even earlier cost calculation undertaken at Keswick in 1570, when Daniel senior was manager [H. Jones, 1985, p. 6; Rees, 1968, Vol. 2, p. 413n], with that reproduced in Figure 2 below, dated c. 1600. The importance of the Germans' presence in 1570 is shown in the report that "If the Company [Haug, Langnauer & Co.] were to break off and leave the works, we have no Englishmen that have skill to take them in hand" [Rees, 1968, Vol. 2, p. 413n].

It is likely that Daniel senior would have been aware of the importance of accounting for mercantile purposes and informed about accounting practices from his involvement with the family merchant business and his association with other Augsburg merchants. More importantly, it is probable that Daniel senior was instructed in cost accounting when training in the Rauris mines. The Tyrolean copper and silver mines and smelting works were technically the most advanced at this time and Garner has found some of the earliest evidence of cost accounting in this industry [1954, pp. 4-7]. The accounts of the Fugger family's mining and smelting activities, covering the period 1548 to 1655, display an approach to costing comparable to that at Keswick, and it is highly plausible that methods similar to those used by the Fuggers were employed at the Wieland family mining and smelting works, where Daniel trained in the 1540s.

What is certain is that Daniel senior and the other German partners in the Mines Royal Co. placed great importance on

accounting. It was they who, in the early 1570s, pressed their English partners on a number of occasions for the appointment of an "honest person with knowledge of accounts to assist them in their negotiations for obtaining wood, peat and charcoal", arguing that such a person could save the company a considerable amount of money and that the "longer the appointment of such an accountant was delayed, the greater the loss" [Rees, 1968, Vol. 2, pp. 413-4].

THE COSTINGS

This section contains a summarized and annotated version of a sample (six items out of 17) of the costings produced by Hechstetter. Inverted commas are used to indicate reproduction of the original wording where the meaning is unclear or to convey the flavor of the times. The original calculations use mainly arabic numerals, but there is some use of roman numerals for quantities, dates and values.

Cost of mining 30 kibbles of copper ore in a week at Goldscope in the early seventeenth century [Hammersley, 1988, pp. 118-19].

The financial statement reproduced as Figure 1 deals with the mining activities of the company, and is a calculation of the cost, per kibble,[3] of mining copper ore over a period of one week at Goldscope, near Keswick. Because the statement focuses upon cost per unit, the calculation is sensitive not only to the accuracy with which costs are forecast, but also to whether the anticipated output of 30 K can be achieved. The calculations, as in each of the other cases, are supported by a detailed narrative. The financial analysis, reproduced below, comprises four elements:

1. Allowance on the piece-rate basis for each ton of copper ore mined.
2. Extraction costs.
3. Cost of extending the works.
4. Calculation of cost per K.

[3]The kib(b)le was a hoisting bucket used in mines. It is generally thought to have held between 1½ and 1¾ cwt of copper ore. The weight of the contents, however, cannot be exactly defined as it would depend upon local or traditional or personal practice in producing flat or differently heaped containers. The weight would also vary with the density of contents; the kibble of lead was expected to weigh 2 cwt, for example. The letter K is used to denote a kibble in the remainder of this paper. The cwt (sometimes expressed as quintal(l), cs or C) usually weighed 112 lbs, but occasionally meant 100 lbs (when the C was used), or 110 or 120 lbs.

Figure 1

				£	s.	d.[4]
1	26 K mined at 2s. 8d. per K			3	9	4
2	4 K mined at 3s. per K				12	0
	Breaking up ore, at 6d. per K				15	0
	Cleaning out "dead work", or	s.	d.			
	rubble, from workings	1	0			
	Bearings, and oil for the engine	1	4			
	Keeping the wheel	5	0		7	4
	Drawing up water from bottom of mine				4	6
	Wheel repairs				1	0
	Rope for engine		6			
	Candles for hodman and other workers		6		1	0
	Carriage of 30 K of ore at the rate of 23s. 4d. for 120 loads				5	10
3	Extraordinary charges: miners' wages for lengthening the works at 40s. a fathom is £5 14s. 8d. for 26 weeks, so for one week				4	4
	Cost of 30 K			6	0	4
4	Which is equal to 4s. for 1 K					

Hechstetter recognized that an increase in the quantity of minerals extracted each week would reduce the unit cost: "if xl [40] kibles be weekley gotten the kible will coste iij [3]s 9d" and "If the helpe money grow lesse or the worke softer the charge will also abate". The revised cost per unit calculation is of particular interest since it has not been reduced in direct proportion to the hypothetical increase in the quantity of copper ore mined from 30 K to 40 K. This implies that the adjusted figure is based upon calculations which recognize that some costs will increase with the level of activity, while others remain fixed. Thus it would seem that Hechstetter distinguishes between and utilizes fixed and variable costs in his calculation.

Trial smelting of Coniston ore, c. 1600. [Hammersley, 1988, pp. 122-4].

The trial involved processing 100 K of Coniston copper ore to discover "what 1 cs of Copper soe made outt of that quantity doth cost". The cost statement (Figure 2) sets out the various

[4]Before the decimalization of British currency, there were 12 "old" pence (d.) to the shilling (s.) and 20 shillings to the pound sterling (£).

labor and material costs involved in the conversion process. The inclusion, in some cases, of round sum daily allowances may be either indicative of a broad estimate, the result of a detailed costing calculation which is not disclosed, or the sub-contracting rate for the work.

Figure 2

	£	s.	d.	£	s.	d.
Bringing 100 K of Coniston copper ore						
ore to the roast: 42 horse loads						
(of peat?) at 6d.	1	1	0			
labourers' wages		3	0	1	4	0
Melting ore for 13 days to produce						
47 cwt of greenstone "at the						
least doth cost 10s" per day				6	10	0
Roasting greenstone in five fires:						
60 loads of peat	1	10	0			
labourers' wages		6	0	1	16	0
Further melting of greenstone,						
four days at 9s. per day				1	16	0
Further roasting in four fires:						
24 loads of peat		12	0			
labourers' wages		1	0		13	0
Cost of melting the roasted ore					10	0
Further costs associated with melting:						
12¼ cwt of "blacke copper" and						
6 cwt of thin copperstone:						
1 fathom of roasting wood		9	0			
12 horse loads of peat		6	0			
labourers' wages		1	6		16	6
Cost of further melting in the						
refiner's furnace — one day					16	0
Carrier of coal						7
Allowance for charcoal, 10½ seams at						
40d. each				1	15	0
Cost of making 13 cwt 2 quarters of						
"good rough copper"				15	17	1

Hechstetter calculates the cost of one cwt as £1 3s. 6d. and comments, perhaps more in hope than judgement, that "which if it were done in the greate woork I know wilbe at the least 2^{s} lesse".

Profit on making copper near Keswick throughout the year 1615. [Hammersley, 1988, pp. 82-5].

The calculation starts with an estimate of how much copper the firm might expect to produce as a result of mining 4161 K of copper ore, of varying degrees of purity, at three locations during 1615.

Figure 3

	cwt.	qu.
2604 K of ore mined at Coniston yields, at the rate of 1 cwt of copper for 8 K of copper ore	325	2
637 K of ore mined at Gassgarth and Newlands yields, at the rate of 1 cwt of copper for 10 K or copper ore	63	3
920 K of ore mined at Coniston and Newlands yields, at the rate of 1 cwt of copper for 12 K of copper ore	76	3
	466	0

It was discovered that only 436¾ cwt. of copper were actually produced, and Hechstetter then proceeded to calculate the costs and profits associated with the production and sale of that amount. The analysis, set out in Figure 4, comprises five stages:

1. Weekly costs associated with smelting, multiplied by 52 to give an annual figure.
2. Cost of copper ore delivered to the smelter during the year.
3. Miscellaneous material costs expressed as annual amounts.
4. Miscellaneous items, including the royalty due to the monarch which is fixed at the value of one fifteenth of total output.
5. Profit calculation.

The profit figure is based on the assumption that the entire output of 437 cwt can be sold, presumably at the current market prices, as a note attached to the original manuscript indicates that only just over 362 cwt of copper was actually sold during 1615.

The costing statement is followed by a comparison with the results of the trial smeltings of Coniston copper ore (Figure 2)

and Tilberthwayt copper ore, undertaken at Keswick in 1600. The conclusion reached is that it "will cost vs no less to bringe the same into Rough copper than [those] ij [2] sorts . . ."

Figure 4

		£	s.	d.	£	s.	d.
1	Weekly charges:						
	4 skilled labourers plus each their man				1	12	0
	Watchman					3	4
	4 labourers					12	0
	Carriage and charcoal-burning					2	6
	Limestone					6	0
	Sieves and scuttles					1	5
	Wallstone					1	6
					2	18	9
	Forging 8½ cwt of copper at 4s. 8d.				1	19	8
	Smithswork in smelting and hammer house					10	0
	Carpenters					15	0
	Timber at £13 per annum					5	0
					6	8	5
	Payment to "officers" (clerks and like employees)					10	0
	Travelling costs (inspecting mines, contacting customers, etc.) and cost of keeping horse					6	8
	Total smelting cost per week				7	5	1
	Smelting cost for 52 weeks				377	4	4
2	Cost of 4161 K of copper ore delivered to the smelter				962	13	0
		£	s.	d.			
3	Peat	333	6	8			
	Stonecoal	150	0	0			
	Charcoal	120	0	0			
	Wood	30	0	0			
	Lome	10	0	0			
	Slates and slater	5	13	4	649	0	0
4	Journey to London				13	6	8
	Rent				160	0	0
	Royalty, one fifteenth of 437 cwt = 29½ cwt at £4				118	0	0
	Interest "for mony above our 1200 stock"				100	0	0
					2,380	4	0
5	The 437 cwt of copper can be sold for £2,605 leaving "clear onto the farmers the some of 1i 225".						

Estimated cost of making one cwt. of rough copper from 9½ cwt of copper ore in a shift, c. 1600. [Hammersley, 1988, pp. 114-17].

Figure 5 contains an estimate of manufacturing costs for a shift, made some time between 1598 and 1603. There are five stages in the financial analysis. Stages 1 to 3 list the costs which can be identified directly with a single shift — called the "ordinarye charge" — and abates forecast output, accordingly, to find cost per cwt. Stages 4 and 5 list a range of annual figures for what today would broadly be described as overhead costs (called by Hechstetter "extraordinarie charges"), and divide the total by expected annual output to produce, again, a figure for cost per cwt. The individual stages are as follows:

1. Cost of copper ore consumed in an individual shift.
2. Labor and material costs associated with each stage of melting and roasting.
3. The produce of a shift — 1 1/5 cwt of copper — is expressed in terms of cost per cwt, distinguishing between the cost of the initial copper ore input and conversion costs.
4. "Extraordinarie charges", expressed as annual amounts, are divided into two categories: costs associated with vessel manufacture (see Figure 6 below), and costs associated only with the manufacture of rough copper. One third of the total cost is apportioned to vessel manufacture. The total is divided by the expected yield of 468 cwt to give a cost per cwt.
5. The royalty due to the Queen.

Hechstetter then considered the implications of his calculations, and again displayed a fairly clear awareness of differential cost behavior and the impact on cost per unit if the quantity of copper ore mined fell below expected production, stating "yf 72 kibles of ewere be not gotten weekely the certaine charges of the officers and reparations must be charged vpon that which is gotten which will then add an increase of charges upon a quintall".

The impact of changes in the yield from copper ore is also explored:

> "if the ewers [copper ores] prove leaner than 8 kibles quintall [i.e., if more than 8 kibles of ore are required to produce 1 cwt of copper] the charges of make=inge the quintall will increase and beinge willde will consume more tyme and labour on rosteigne. But if more kibles the 72 shall be weekly gotten or the ewers grow richer they viij [8] kibles to yeald a quintall or the rocke softer then this charge will abate . . . "

Figure 5

					£	s.	d.
1	2 barrowfulls of Coniston ore, plus 2 barrowfulls of Newland ore, plus 2 barrowfulls of once roasted Coniston ore, equals 9½ cwt at 4s. 3d. per cwt.				2	0	4
2	9 loads of peat for the furnace, at 6d. per load		s.	d.			
			4	6			
	5 loads of stonecoal at 8d.		3	4			
	Coal dust and white clay for plaster(?)			2			
	Limestone to make copper ore run			6			
	Master melter, per week	9s.					
	2 other melters at 5s.	10					
	3 workmen at 3s.	9					
		28					
	15 shifts a week (to take account of holidays and "casualties", gives per shift		1	10		10	4
	Cost in labour and peat in further roastings "each fire greater than another"					5	0
	Separate roasting of the Coniston ore						10
	Cost in labour and peat of first melting in smelting furnace					3	0
	Peat and wood costs of six or seven further roastings of copper stone					2	6
	Cost of bringing roast copper "to perfection" in great furnace and transferred to the refinery where it is refined "with purest charcooles and made into rough copper"		s.	d.			
	8 loads of peat		4	0			
	3 loads of stonecoal		2	0			
	Extraordinary plaster		0	4			
	Melters		1	10			
	Carrying charcoal			3			
	Charcoal		7	6			
	For six cwt, which for 1 1/5 cwt is					3	2
	Total cost of 1 1/5 cwt of rough copper				3	5	2

Figure 5 — (continued)

					£	s.	d.
3	Equivalent cost of 1 cwt of copper ore				1	14	0
	making into rough copper				1	0	8
					2	14	8
4	Extraordinary charges, per annum	£	s.	d.			
	Watchman at 6d. per day gives, per annum	9	2	6			
	Three labourers to carry peat and coals to the furnace and hammer at 8s. per week gives £20 8s. 0d.	23	8	0*			
	Buckets, rods, sieves and trays	3	0	0			
		35	10	6			
	Two thirds (one third charged to production of copper vessels — see below)	23	13	8			
	468 cwt produced in a year, gives for 1 cwt		1	0⅛			
	Further annual charges:						
	Blacksmith's charges for repairing tongs, forks, water wheels, and the tubes conducting air to the furnace	£10					
	Renewing and repairing bellows	5					
	Lamp oil for melters	1					
	Candles for watchman	1					
		17					
	468 cwt produced in a year, gives for 1 cwt			9⅜+		1	9½
	Hogs' grease (lubricant for bellows) for 1 cwt						1
5	Royalty					3	11½
					3	0	6

* It seems likely that either the 8s per week or the £20 8s. 0d. is a mistake as a figure of £23 8s. 0d. is needed to balance the list with all the other totals provided.

+Does not tally exactly.

Estimated profit arising from the conversion of 1 cwt of rough copper into malleable copper and forging into vessels, c. 1600. [Hammersley, 1988, pp. 117-18].

This analysis (Figure 6) takes the previous calculation a step further by estimating the cost of making copper vessels from 1 cwt of rough copper. The stages are as follows:

1. Cost of 1 cwt of rough copper, as calculated above.
2. Labor and material costs involved in forging, hammering and metal polishing.
3. Annual charges from blacksmith plus the ⅓ apportionment of the "extraordinarie charges" (as calculated above), divided by expected output to produce figures for cost per cwt.
4. Labor and materials involved in the repair of fixed assets plus travel costs and a clerk's wages.
5. Total cost compared with the sales price of copper vessels.
6. Estimated profit per cwt multiplied by the estimated annual produce of rough copper (437 cwt) to give a forecast of yearly profit.
7. The existence of unrecognized further costs is acknowledged.

Figure 6

			£	s.	d.
1	Cost of manufacturing 1 cwt of rought copper		3	0	6
2	Forging sub-contracted to Sebastian Dibler and his son			9	0
	Vessel polishers: labour			1	7
	Materials (vinegar and salt)				2
3	Smiths charges hammers, barrows, iron and steel				9¼
	Wages of watchman and labourers to carry peat and coal, allowance for scuttles, etc.				6¼
			3	12	6½
4	Wages of Mr. Carpenter and son, per annum	£39			
	Timber for repairing bellows, water wheels, hammer, shafts, barrows	20			
	Travel costs and clerk's wages	24			
		83			
	Proportionately, per cwt, on 437 cwt			3	9¾
5	Sum total of all charges		3	16	4¼
	Copper vessels sold at melting house, per cwt		4	10	0
	Profit "clearly gained"			13	8
6	Which for 437 cwt per year is		299	1	5
7	Out of which sum is to be deducted the "officers" allowance, yearly rent and interest on money above £1,200 stock.				

The calculations are again followed by a narrative which indicates an awareness of the effect of possible changes in the level of production, and also the need for differential pricing in certain geographical areas. Apparently, the firm was willing to accept a price of less than "xiiij nobles" (14 × 6s. 8d. = £4 13s. 4d.) for copper in London, and that this departure was balanced by the fact it could sell some at £5 12s.

'Capital' expenditure at Keswick, pre-1605. [*Hammersley, 1988, pp. 119-20*].

Introductory remarks refer to the fact that the company had an initial £1,200 "stocke" and that Emanuel and Daniel Hechstetter made further injections amounting to £650 following their entry into the firm. The financial statement (Figure 7) is a crude valuation of the business, probably made in 1601 or early 1602, to find out what had happened to the money and how they now stood.

Figure 7

	£	s.	d.
Engine at cost	301	0	0
Sinking shaft and draining drifts at Caldbeck	70	0	0
Further sinking and draining at Coniston	30	0	0
Workmen's (and other) debts	150	0	0
Stock of charcoal at the melting house	133	6	8
Stock of stonecoal at the melting house	66	13	4
Stock of colling wood	20	0	0
Stock of peat at the melting house	100	0	0
Stock of copper (ores and roasts, i.e., not finished copper), 120 cwt at £4 (per cwt)	480	0	0
Stock of copper ore at the melting house and mines, 600 K	150	0	0
Stock of roasting wood	30	0	0
Stock of iron	20	0	0
Lost in partnership with Mr. Smith	135	0	0
Copper lost at sea	40	0	0
Repairing and mending roasthouse and copper furnace	30	0	0
Stock of clay	5	0	0
Horses	6	13	4
Stock of stonecoal in Coniston and Newlands	6	6	8
Stock of charcoal in Coniston for the blacksmith	2	0	0
Stock of Caldbeck copper ore	30	0	0
Materials for bellows	40	0	0
Cash in hand	95	0	0
	1,941	0	0*

*Total should be £1,951 0s. 0d.

Most of the items listed above would be considered appropriate for inclusion in a present day business valuation. The method of valuation is not given, except in the case of the engine, and it is not clear whether cost, market value or some other measure is used in the remaining cases. The status of the partnership loss is not clear, but it is possibly John Smith's share of a loss arising when he was a member of the partnership and which it was still hoped to recover.

CONCLUSION

Costing calculations made as a matter of systematic routine will be the product of a formal system of bookkeeping, which is quite possibly integrated with a company's financial accounting system. The earliest examples of records maintained in this form in Britain or the United States date from the late eighteenth century. It is well known that costing exercises undertaken for particular purposes — sometimes described as *ad hoc* costing — have even earlier origins [Pollard, 1965, p. 219ff]. A significant feature of the Hechstetter records is that they exhibit advanced features of this version of accounting undertaken at the very beginning of the seventeenth century, about one hundred years before further evidence of such practices is available.

An *ad hoc* costing calculation may take the form of an *ex ante* estimate, made as the basis for deciding whether to invest in a particular activity and/or to serve as a standard against which actual performance can subsequently be measured. Costing calculations may also be made *ex post* to assess the profitability of products and to help monitor the performance of individual workers. Such calculations may be made on an actual or estimated basis.

Most *ex post* calculations made in the seventeenth century, and much later, were probably estimates of actual costs incurred, relying on the businessman's intimate knowledge of his trade, rather than precise financial calculations based on carefully maintained accounting records. This might well have been because the accounting records were insufficiently reliable or comprehensive to allow actual costs to be ascertained, or because the time and cost involved would not have been justified in terms of the expected benefit to be derived from a more exact calculation, particularly in circumstances where the owner and/or manager remained in close contact with all aspects of day-to-day activity [Edwards and Newell].

It is not immediately obvious into which category of costings each of the six calculations reproduced above falls. Hechstetter knew how he had made the calculations and, because he was also making the decisions based on the information obtained, found it unnecessary to point out the precise stage at which each was made. Moreover, the authors' inability to translate accurately all that was written acts as a further constraint in exploring fully the ramifications of the calculations. Bearing in mind these difficulties, it is nevertheless possible to make some assessment as to how the calculations were determined and to what uses they were put.

The calculations reproduced in Figures 1, 5 and 6 are estimates of actual costs incurred in extracting minerals and manufacturing copper, made in the hope of reassuring management that it was worthwhile continuing operations in an industry in which a substantial amount of money had been invested. The trial smelting (Figure 2) was an experiment undertaken to discover the costs which *should be* incurred as a yardstick for judging future performance, while the calculation in Figure 4 combined actual costs incurred with estimated revenue as a basis for monitoring performance during 1615. The inventory prepared at the beginning of the sixteenth century (Figure 7) was used to identify the company's current position.

The calculations are rudimentary and there is no way of judging their accuracy. Furthermore, it is impossible to assess their usefulness for making management decisions. Certainly the company failed to prosper, but whether poor accounting data contributed to this lack of prosperity remains a matter for speculation. Since trading conditions at this time were unfavorable, however, it is equally plausible that the determined efforts of Hechstetter to subject business events to financial analysis paid dividends in the sense that the company did better and survived longer than would have otherwise been the case.

While no assessment as to the impact of the use of cost accounting on business performance at Keswick can be made, it is nevertheless possible to glean information about the accounting methods employed. Irrespective of the quality of individual figures, it is clear that a significant number of costing concepts which remain in widespread use today are recognizable either implicitly or explicity within these calculations undertaken nearly four hundred years ago. These include:

1. The identification of costs associated with individual inputs.

2. The distinction between direct and indirect costs (called "ordinary" and "extraordinary costs" at this time).
3. The distinction between material costs and other direct costs.
4. The calculation of total costs.
5. The calculation of unit costs.
6. The association of costs with their natural time horizon, e.g., a shift or a week or a year.
7. The ability to equate costs associated with different time horizons.
8. The apportionment of joint costs between different activities.
9. A rudimentary system of process costing.
10. A recognition of differential cost behavior.
11. An awareness of the impact on unit cost of changes in the level of production due to variations in mining and manufacturing conditions.
12. An awareness of the logic of charging what "the traffic would bear" in order to maximize profit.

The Hechstetters' approach to business has been contrasted with what is known of native British industry in this period, and the lack of sophistication evident in other surviving business records has led to the Hechstetters being described as "professionals in a land of amateur industrialists" [Hammersley, 1973, p. 25]. Whether this was indeed the case may never be definitively established.

As it stands, the identification of the use of a number of modern accounting procedures, as early as the turn of the seventeenth century, is of considerable interst to accounting and business historians. In broad terms, it throws additional light on the possible contribution of accounting procedures to business decision-making in the early stages of industrial development. At the more specific level, the fact that the Mines Royal Co. accounts pre-date the industrial revolution by a considerable margin demonstrates that when faced with unfavorable economic conditions at least some businessmen responded in a similar manner to their more celebrated successors of the eighteenth and nineteenth centuries.

These findings add support to the persuasive "demand/response" theory of accounting development, which sees accounting as a "social technology", continually responding to changes in business requirements. In this respect, prevailing economic conditions, the nature of business organization and the willingness of management to innovate combine to dictate,

to a large extent, what accounting practices will develop. At the same time, it must be accepted that the findings demonstrate a certain consistency — perhaps even inertia — in accounting practice. This might mean, in terms of the "demand/response" characterization, that certain basic accounting requirements have remained stable over a considerable time period. A quite different interpretation is that accounting systems are less flexible than is sometimes imagined.

With regard to the German influence on seventeenth century accounting practices in Britain, the lack of surviving records makes it difficult to assess whether the accounting methods employed at Keswick diffused to other enterprises or whether they were redevised independently elsewhere. Mining and smelting in Cumbria certainly stagnated after the closure of the Keswick works, but metal industries developed in south Wales near to where Ulrich Fross had smelted copper, and where evidence for the use of similar accounting methods is next found [H. Jones, 1985]. It is not inconceivable that a migration of labor from the copper works may have resulted in a transfer of accounting methods elsewhere, or indeed that later generations of migrant German metallurgists brought similar accounting expertise to Britain [cf. Day, 1984] to form the basis of the better documented advances of the eighteenth century [H. Jones, 1985, Edwards, 1989]. In the absence of records for the intervening period, this must remain a matter for speculation.

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