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QUANTIFYING AND QUALIFYING THE VALUE OF ERGONOMICS TO BUSINESS

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If ergonomics is to come of age and be welcomed into the business community then the question of its value must be addressed. What is the financial value of ergonomics to business, and how can this value be qualified and quantified by ourselves and, most importantly, others. Six aspects of value are considered with respect to the incorporation of ergonomics into the activities of business.

Introduction

Value, like motivation or quality can be described as having “face validity”. We all, and I do mean all, know exactly what is understood by such terms, until we consider the terms in detail. The lack of precision in these terms becomes more obvious as we delve into the literature and talk with “Experts”. It is possible to distinguish, at least six, commonly used, aspects to the term *Value*.

1. The **value** of something such as quality or a method is its importance or usefulness. *Everyone realises the value of ergonomics.*
2. The **values** of a person or group are their moral principles and beliefs. *Ergonomists have different values from the organisations they serve.*
3. If you **value** something, you think that it is important and you appreciate it. *Which do Product Designers value most, ergonomics or aesthetics?*
4. **Value** is used after another noun to imply that something has a particular kind of importance or usefulness. *It might not look best but it is the safest, ergonomics does have value.*
5. When experts **value** something, they decide how much it is worth. *The value of the ergonomics contract to the University was a Lectureship.*
6. The **value** of something you own or control is the amount of money it is worth. *Manufacturers should add value to their products by improving the ergonomics.*

(After Sinclair 1992)

Each of these aspects will now be considered in turn.

Value definition 1

“Everyone realises the value of ergonomics.”

Ergonomics was born in the Second World War and grew throughout the period of the “Cold War”. Clearly the need for ergonomics, or as the American would then have it, Human Factors Engineering, was self evident. “Our” weapons must work effectively and be ready in time to counter “their” weapons whenever and wherever they were deployed. Budgets were large, “scientific method” was popular and confidence in scientists was high!

Ergonomists working in the military and related fields could point to their successes, or more likely, the failures of others, (often engineers) and obtain work. There was, of course, the constant gripe that the ergonomist became involved in the project too late and that critical (I mean to imply "wrong") decisions had already been taken. However, that could just be seen as establishing the alibi! Ergonomics was, obviously, a good thing but not everybody realised it! In the “white heat” of technological advancement there was nothing an ergonomist could not do! Ergonomics was, just “Common Sense” confounded by technical jargon, just as Bronowski (1951) argued all Science was!

This modest certainty still prevails in many academics, researchers and, to a lesser extent, practitioners! However, just because we know the value of ergonomics not everybody else has the confidence we do! Business is, for example, sceptical and must have the worth of the

subject justified to it in the financial terms that it understands!

We know that ergonomics is not a theoretical subject, it is the application of knowledge and experience to a human activity system with the intention of minimising any undesirable factors. It is a holistic amalgam of all its root disciplines. We must seek to get these points across by demonstrating the subject's worth. It is, of course, good to have confidence in the product; now we must ensure that everybody else learns to have it too.

Value definition 2

“Ergonomists have different values from the organisations they serve.”

Those at the announced birth of ergonomics, in 1949, (Murrell 1965) clearly could not be pure ergonomists as their original training had already occurred; Society at this time lacked knowledge of the appropriate terminology. Just as the first “Physicists” described themselves as “Natural Philosophers” or Mathematicians the founders of our discipline were to be found working under various titles. The cover of Alphonse Chapanis’s 1959 classic (1965 printing) notes him to be a Professor of Psychology and suggest that the book should be filed under “Business, Economics”. (Sadly not the last time that our discipline has found itself filed under economics!)

Ergonomics was created from an amalgam of other subjects and disciplines at a time when University Departments or Research Groups did not emerge quickly. Thus the early ergonomists operated in Departments in which they qualified but undertaking tangential or novel activities. This would also be true in Industry where ergonomists might be found in Personnel Departments, Safety Offices, and Engineering, Design or Medical Groups. With some enlightened and meritorious exceptions the same is true today.

The multi and interdisciplinary nature of the subject will always remain and many of those who could describe themselves as ergonomists still prefer to attach themselves to an area perceived to be more established. In the past year I have met Biomechanists, Heating Engineers, Health Chemists, Physiologists and Psychologists who have produced ergonomic reports. Many of these people could describe themselves as ergonomists but choose not to do so. When asked why they did not describe themselves as ergonomists, the most common reasons given were the title of their posts followed by a lack of understanding of ergonomics in Society. I experienced the reverse when I applied for a Lectureship in Ergonomics at another University only to find that the workload was virtually all physiology and biomechanics; apparently the “wrong” title was being used for internal political reasons!

I too must admit that I have, on occasions, avoided the inevitable confusion with “economics” or “work-study” and described myself as a Practical Philosopher! We must

seek to remove these misunderstandings, often of our own making, and we must adopt the techniques of business to demonstrated the benefits to be obtained from using ergonomists. The values of the ergonomist concerning the well-being of people, the belief of solution obtained via inquiry must become recognised as important but this is unlikely to happen until our “eccentricities” are more widely known and our attributes financially justified. We must all work to over come our ignorance of the ways of business before we can overcome the comment so often heard when ergonomists meet; “why doesn’t my boss understand me!”

Value definition 3

“Which do Product Designers value most, ergonomics or aesthetics?”

When faced with a decision between two products designed to undertake the same task does the potential purchaser select the one that looks good but might not work or the one that works but looks less good? To answer this question more information is required, perhaps most importantly what tests can be undertaken by the buyer? Do they have the option of a trial? Will they undertake realistic tests or just rely on intuition, initial perception, looks and the brand name?

Well this is, of course, the wrong question. How we get others to value ergonomics? How can we sell ergonomics and show that products incorporating “good”

ergonomics work better than those that do not. Are we, as a professional society, even able to agree on what good ergonomics is?

Clearly if we are to encourage the general public to value ergonomics then we must emphasize when it has been incorporated and draw attention to the benefits that follow. These are early days but this is increasingly occurring. Some specific products, notably work seating, have been endorsed by respected ergonomics. These, and others, have been involved in particular products from the earliest design stages, however, these examples are rare and not without controversy. Consider, for example, the debate concerning the Maltron Keyboard and its role in the prevention or cure of “RSIs” or, as is now generally preferred, “WRULDs”. I can recall seeing versions of this keyboard at exhibitions in the early 1980s yet it appears that the definitive, accepted by all, research to validate the design has yet to be undertaken. As recently as the November 1994 issue of “The Ergonomist” the originator of the keyboard is suggesting that an appropriate organisation should seek funds to undertake the experiment! (This cycle of the debate started in October 1994 issue.)

Of course, not all of those claiming that their products are “ergonomic” are concerned about the niceties of justification or attribution. For example, a pen allegedly based on “the ergonomic perfect shape of an egg” may be fine if you want to lay it but why should it be easy to write

with? How can we ensure that ergonomics is appropriately applied, understood and thus valued by the general public?

Perhaps one way forward is to join with the Professional Societies of others involved in the design and production of products to fight for individual credits. For example, an Architect will display a board on a site and a typical Film, might credit 100 people from the most famous actor down to those that provided the catering or accountancy services. The Swedish company IKEA often acknowledges the Designer of the product but what about the others involved? Perhaps, the work of the identifiable ergonomist/ergonomics group will be valued and sought out by prospective purchasers. (I may not be able to tell which firm of accountants were used by watching the film but other film makers recognise the names and, I expect, seek out those successful in keeping the production within budget!) Good product ergonomics may not be obvious either but the lack of it could concern or injure the user.

The manufacturer and supplier might also welcome the labelling of products with details of those concerned with their production. The clear identification of responsibility could be important if recalls were required or a legal action started under the recent EEC driven Consumer Protection Regulations (SI 1994:2328). (This legislation would appear to offer another approach, for a plaintiff seeking to establish liability if they were injured while operating equipment supplied by others. I would expect to see, for example, cases concerning injured “keyboarders” before the Courts in due course The regulations do, however,

offer a defence of “due diligence” and this could be expected to benefit from crediting those involved in the product’s design and manufacture.)

Value definition 4

“It might not look best but it is the safest, ergonomics does have value.”

Once we can define what constitutes good ergonomics and provide the information by which the purchaser can check a product or service we must ensure that it is recognised and acted upon. At present, even when a design includes some well thought out ergonomic features the marketing people tend to use it only as jargon. The benefits of the ergonomics must be shown to be self evident and not just regarded as some cynical Unique Selling Point (USP). Ergonomics must not be held in the same regard as the P45 fluoride formulation included in the stripes of the, apparently “ideal” toothpaste!

Virtually any marketer will tell you that ergonomics can help sell products but that it is rarely a “contract clincher”. For example, could you find office furniture designed to support computers that was not sold as “ergonomic”? I doubt it! In this market the term “ergonomic” has value but this value is not often quantified by ergonomists. The marketers using the term may not understand our subject nor treat it with respect. Graphic equalisers, described as ergonomic, appear, for example, to be an essential part of “budget hi-fi” systems. Yet when

you pay more the idea that you should modify the sound on the CD or watch the jumping green lights is rejected; the display and tone controls are removed; “Source Direct” is the desired requirement.

I know of a company manufacturing an “ergonomic” steam iron that had a simple three position steam switch; off, half and full rate. The iron did not sell well and studies suggested that one reason was that the irons of their competitors had greater adjustability. The solution was to change the switch, not the mechanism, into a knob and make it click ten times as it was rotated. A “flash” was added to the box - “Now with 10 position steam control”. Sales increased dramatically! The replacement of a three position switch with a three position, ten click, rotary control would not be the normal advice of an ergonomist but to the marketing department this design change “added value” to the iron!

If we are to educate the general public then we must all do our part. Speak on Broadcast Media, write in the press and generally work to spread the word as wide as possible.

Value definition 5

“The value of the ergonomics contract to the University was a Lectureship.”

Who are these “Experts” that might value ergonomics for others? In the case of a Domestic Product then the question about what something is worth is usually answered by the statement that it is worth what you can sell it for. This might appear glib but it is undoubtedly true. (Would you covet a cheap Porsche, buy low priced perfume or, without reservation, employ an “Expert” who only charges 1/5 of the market rate?) Can ergonomics be good if it is cheap, perhaps it is just applied common sense!

Perhaps “ergonomics” cannot yet be valued, for domestic products, because the market place is not aware enough of the benefits and the information required to identify those applying ergonomics is not displayed. However, we are generally selling not to the general public but to manufacturers, Product Designers, Government Agencies, etc. Perhaps we are too cheap!

Until the last decade most ergonomic advice available, other than in-house groupings, came from academics or University Departments/Research Groups. I fear that many of these, historically, did not charge commercial rates for their help. They also suffered from the perception that it was often the precision and rigour of the research work required for PhD opportunities that was for sale and not a near correct answer later that afternoon. Thus the

valuation was undertaken according to different criteria by prospective client and consultant.

Recently two other groups have entered the market and are offering advice on ergonomic problems. This advice is often very cheap and appears to come from; “just finished” students testing the “freelance experience” and professionals in related disciplines with spare capacity. In the case of the latter I have been undercut by a local General Practitioner Practice (Doctor, Physiotherapist and Nurse) and a Marketing Agency seeking work for a Placement Student studying Personnel Management! Their “ergonomics” is unlikely to be comprehensive or of an appropriate standard but it was, apparently, cheap.

Discussions concerning the rates charged by those seeking ergonomics Consultancy work are, usually, candid. However those offering to work in the Health and Safety Field could have a listing in The Health & Safety at Work Journal. This publishes listings (Table 1 overleaf) under 28 categories of activity of which one is “ergonomics”. The only other category that closely applies to our sphere of activity was “Manual Handling” as “Office & Buildings” was generally used by those offering environmental monitoring from an Occupational Health. The activities are classified under two headings; “activities most commonly carried out by the consultancy” or “other activities within a Consultancy’s scope”. There was growth (26%) in Consultancies offering ergonomics between the 1990/1 and 1994 editions at the same time as the number of Consultancies listed dropped by 33%.

The daily fees quoted as charged by the Consultancies are, in most cases given in wide bands (£150-£450 is typical) while others did not provide any details. In the 1994 list the mean daily rates quoted for all Consultancies excluding those offering ergonomics can be estimated as £421 (Bands 200-225 to 800-825) while the £383 (Bands 150-175 to 675-700) and £340 (Bands 150-175 to 625-650) are the estimates for those organisations offering ergonomics either as a main (n=16) or subsidiary (n=13) activity respectively and providing fee details. Table 2 (overleaf) shows how daily fees have changed during the 1990s over a period during which inflation was about 25% and suggests that competition is pushing down the fees charged for ergonomics and thus the perceived “value” is also falling!

Table 1. Summary of Consultancies listed. (1990/1 was a biannual listing).

	Totals (%)		“most commonly”		“other”	
	1990/1	1994	1990/1	1994	1990/1	1994
All Consultancies listed	227	151				
Those offering “Ergonomics”	23 (10%)	29 (19%)	14	14	9	15
Those offering “Manual Handling”	23 (10%)	54 (36%)	18	11	5	43

Table 2. Comparison of Mean Daily Rates (£) between 1990/1 & 1994.

Consultancies	1990/1		1994		Change £(%)
	£Mean	£SD	£Mean	£SD	
All Consultancies	319	116	421	157	102(32%)
“Most commonly” - ergs.	348	112	383	117	35(10%)
“Other” - ergonomics	387	102	340	108	-47(-12%)

The anecdotal evidence for the longer established Consultancies is not so bleak but if the image of Ergonomics as of high value/worth is to be maintained then the perception of falling fees and that ergonomics can be offered by non-ergonomists must be changed. At present, I suspect, Ergonomics Consultancy is too often seen as an additional revenue stream and not the main focus of activity. It must be realised that for the small to medium sized company the option of employing an ergonomist within the organisation does not exist. Thus as they learn the advantages of the incorporation of ergonomics into their structures, their products and services they will expect to discover pricing based upon utility and benefit gained, not just an hourly rate for, perhaps, an unspecified length of time. At the very least the latter approach leads to concerns that the job is being spread out and that the client is being “milked”. Not a reputation we should wish to reinforce, especially for those of us working in Academic Institutions. This, hopefully erroneous, perception of academics is already well established among the general public!

As other areas of activity undertaken by ergonomists do not, as yet, appear to be such a free market as can be found in Health and Safety Consultancy the rates charged are not published. It will be interesting to see what, if any, difference the Ergonomics Society's new Consultancies Register will have to this aspect of value. To what extent, if any, will it monitor fee levels and the quality of service offered.

Value definition 6

“Manufactures should add value to their products by improving the ergonomics”

The possible objectives available in the marketing of products or services, can, according to the Marketing Guru (and no known relation) Michael Porter (1989) be reduced to only two true strategies; Quality ("Differentiation") leadership and Cost leadership. With the obvious exception of Not-For-Profit organisations it is the profitability of their products and/or services that drives the organisation and its Stakeholders.

It is, of course, possible for products and services to be targeted at different niches and thus a “mixed” (“focused”) strategy can be applied. Thus a company might seek to market the "best" kettle at a number of different price points, £14.99, £19.99, etc. It is also true that a company will seek to maximise their market share by offering products/services targeted at different markets. IBM tried that with its “Ambra” products and Ford still

maintains separation with Jaguar, lest people start to view the latter as an expensive Ford. The synergy between BMW and Range Rover is clear but the marketing problems of the reverse must also be considered; could the classic "Mini" devalue the BMW Marquee?

Thus it is only these two aspects (Cost or Differentiated ("Quality") Leadership) of competitive strategy that can benefit from the application or incorporation of ergonomics. However, this view highlights the two fundamental approaches, using ergonomics to improve the service or product offered or to reduce the costs that must be borne by the revenue stream concerned. The model Porter devised is shown in Figure 1.



Figure 1. Michael Porter's Model of Competitive Advantage (1979).

Quality Leadership

I have mentioned earlier some difficulties in the incorporation of ergonomics into a product or service so that the customers' perception of quality within that item is enhanced. This is an area in which we must all work by requesting ergonomic evidence to support both our own

purchases and those we have influence over. How often when considering a purchase do you discuss the ergonomics of the various products explicitly with the sales staff? For example, does your Purchasing Department specify the type of container that supplies come in or does it just specify the contents. I have recently helped a company with a manual material handling problem by training the purchasing department who then specified 25Kg kegs bound to pallets rather than the 50Kg drum that had been previously used. Including this specification in the tender documents did not, I understand, lead to an identifiable additional cost. I am also aware of a company that now specifies “Copier side” delivery for its paper and will not accept delivery elsewhere. In this case it is the delivery driver who brings the pallet truck and transports, in bulk, the paper by the lift rather than the office staff carrying the boxes by hand. (You will note that the Bargaining Power of Customers is an influence identified in Figure 1)

While it is often not easy for us to precisely quantify the financial benefit from the incorporation of ergonomics into a product or service that is really the role of others, the marketing Department for example. The ergonomist by considering “who benefits” and demonstrating marketable coherence with a “Quality Leadership Strategy” can give the “Marketeers” the guidance and confidence to sell ergonomics, surely something they will be better at than we are! This raises the question as to just who is the end/final customer, to whom should we be selling the benefits of

services or products incorporating ergonomics? Thirteen “Customer Groups” can be identified, all of which should be considered during the development, evaluation and modification of any product, service or system.

- **Bystanders** - These people have nothing to do with the product but are affected by it.
- **Figurehead** - The Company or Charity President, who undertakes no day-to-day activities for the organisation.
- **Signature** - A person who settles the account, on the advice of others.
- **Owners** - Those that make the rules by which the product or service must abide.
- **Customer Representatives** - Those individuals or groups, possibly self appointed, who decide what the actual customer may be exposed to and thus have the option of buying.
- **Customers** - Those that buy the product or service but do not, necessarily, use it regularly.
- **Users (regular)** - Those that use the product or service as intended by the designer/supplier and who will seek guidance before going outwith the specified limits.
- **Users (normal)** - Unlike the “Regular” customer these people will “misuse” the product or service but in a predicable and acceptable (although not necessarily advisable) way.

- **Users (abusers)** - Unlike the “Normal” customer they will exceed what could be regarded as “acceptable misuse” use of a product/service.
- **Users (explorers)** - Given a product they will see what it can do, unlike abusers they are not unthinking but investigating.
- **Wreckers** - These are not, in any real sense, users and are generally known as vandals!
- **Installers** - Those that install products may be “naive” or “professional” depending upon the complexity of the product and level of experience they have.
- **Maintenance** - Those that fix it when it has gone wrong. Depending on the product they too can be either “Naive” or “Professional”.

The best inclusions of ergonomics will take into consideration all the above “customers”, encourage desirable/acceptable use and discourage/prevent the unacceptable. In all cases we must seek to minimise the consequences of failure - "fail soft" design. (Any approach can, of course, have undesirable emergent properties. If, for example, secondary car safety had not been improved so dramatically over recent years then “Ram-Raiding” could not happen. The occupants of the car would be so injured during the impact with the wall or window that they would be unable to get out of the car and steal from the

shop! I wonder what the value is of the slogan -
“Ergonomists Made-Ram-Raiding Possible”!)

The stages through which a design is developed from the initial idea or brief through concept development and ultimately to production is well established. (Figure 2. overleaf) Ergonomics can be appropriately applied at all stages and its incorporation must be managed just as the whole design process should be. If ergonomics is not included within in the design process the only opportunities for ergonomists will occur late in the process when the design concept, and perhaps detail, will be fixed. Not only may this limit the options but it is also likely to cause frustration to the individuals concerned. The alternative is to delegate the ergonomics to the designers and rely on the fact that most will have been introduced to the topic during their education. This can be successful but it must be regarded as a high risk approach to delegate to somebody who will know some ergonomics but prefer design! Faced with any tension between looks and usability the former will generally succeed.

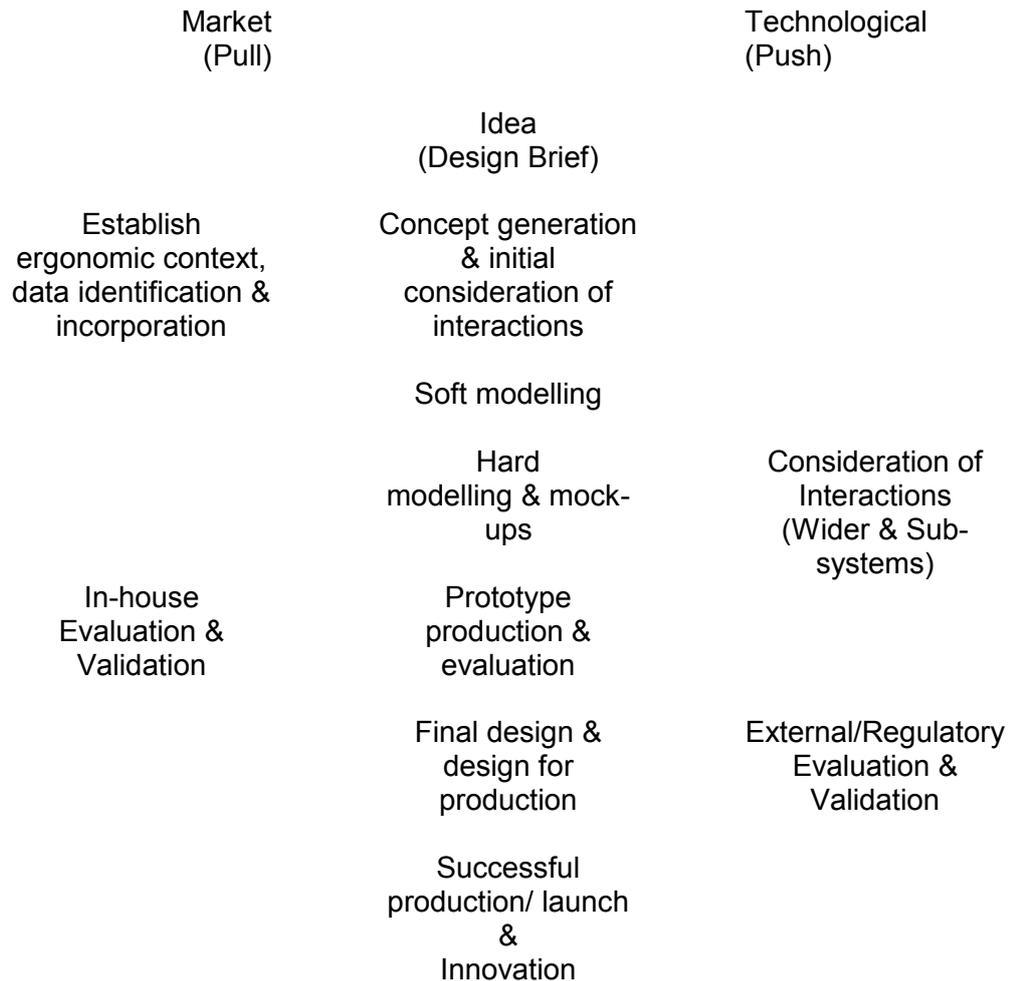


Figure 2. The Product Development Process and the role of ergonomics.

There is also the near fundamental problem that virtually all designers work virtually exclusively with visual representations of the product (2D or 3D and generated by hand or computer). Thus they have difficulty representing or communicating the sound to be made by the machine, the behaviour of the software interface or even the handling properties of the finished design. For example, the handling and pouring of a full kettle is not easy to test

until the final stages of the design process when the "choice" materials and processes are used. By this time the company has invested considerable sums in tooling and is committed. This is one reason why the Designer sells the concept but engineers finish the project and why the management of the whole development process is so important.

There is an other aspect of "Quality Leadership" that need to be considered, the perception of Corporate Quality. For example, you may not know the detail or the product nor be able to test it fully but you do know that XYZ is a "good" name. You feel that you can safely buy their product, even though it might cost a little more than a similar one made by the UVW corporation. The XYZ corporation, of course, know this and charge a premium for their products because of their name! Corporate Image will be discussed, below, in association with the "Cost Leadership Strategy"

Cost Leadership

In the case of the incorporation of ergonomics into a product or service the ultimate customer must be the focus while when ergonomics is to be applied to an organisation its structure must be considered. Mintzberg (1979) identifies six basic parts of an organisation that he represents diagrammatically (Figure 3). Porter's (1985) "Genetic Value chain" would be an alternative model that could be also appropriate.

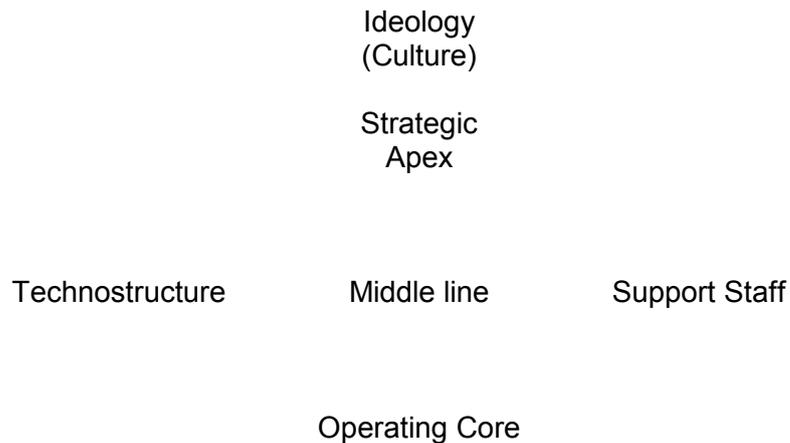


Figure 3. The Structure of Organisations (After Mintzberg 1979).

- **The Operating Core** - Where the basic work of producing the organisation's products or delivering its services is undertaken. Designers design, Workers assemble Televisions, Doctors treat patients, etc.
- **The Strategic Apex** - The home of Top Management, where goals are set and progress monitored with a general (Strategic) perspective.
- **The Middle Line** - The managers that operate directly between the Strategic Apex and the Operational Core. Often the level managing the introduction/implementation Ergonomics and the level most under pressure as "right-sizing" occurs.
- **The Technostructure** - The staff who design the systems by which progresses and the outputs of others are formally designed, monitored and controlled.

- ***The Support Staff*** - Those specialists that provide the support that the organisation needs outside of its direct operations. Public/Corporate relations, Canteen Staff, Legal Counsel, etc.
- ***The Ideology (Culture)*** - The halo of beliefs, traditions and folklore(experiences) that surrounds the whole organisation.

That ergonomics can benefit each of these above organisational areas is, to us, self evident, but we need to establish its value for the company concerned. I would suggest that each area should be evaluated task by task and initially allocated to one of three categories; no significant ergonomic problems or implications; significant ergonomic shortcomings already manifest in accidents, low production rates, slow induction/training speed, etc. and the wide category containing tasks with identifiable sub-optimal ergonomics with quantifiable risks and urgencies. In the latter category the order of attack is usually risk management with financial monitoring and control. From this the agreed Action Plan, incorporating ergonomics within the organisational, can be expected to emerge.

Tasks found to be acceptable may be left until changes are proposed in that structural area or those impinging upon it. At this time the initial “ergonomic audit” will need to be reworked. If major changes are proposed and the ergonomic implications are not readily identifiable then an allocation of funds against future work should be

made. For example, the valuation of a project by discounting its lifetime cash flows is commonly undertaken. Different organisations will use this information in different ways both to compare projects competing for funding and to establish targets for the revenue stream. Net Present Value (NPV) and Internal Rate of Return (IRR) are commonly used and by increasing the Discount Rate employed (to cover the risk that additional ergonomics work will be required in the future) an underestimate of the project's profitability is produced. This will ensure that the project budget contains an allocation of funds for, as yet undefined, ergonomics work. Thus the financial measure selected is used for project comparisons in the usual way but modified to explicitly cover the risk (not a certainty) of future expenditure on ergonomics. Of course predictable expenditure must be specified and included in the calculations.

In the case of task with an identifiable risk the longer term solution will probably involve the same type of discounted cash flow costing as described above. However, with longer term projects the predicted expenditure might just not be enough. A more comprehensive argument will be required to help the valuation of the problem and thus the quantification of the ergonomics element.

Inevitably the first question is whether or not the problem is of sufficient size to risk the whole organisation. In the case of many multiple claims or a significant undesirable public event occurring this is not an

unreasonable question to ask. What is the level of identifiable risk that the Board wishes to accept and what will it do to insure/hedge bigger risks? Figure 4 shows how such undesirable events might be initially considered.

<p>high numbers/ severe injuries (death)</p> <p>Number and severity of injuries per event (incident/accident)</p>	<p><i>Major Accident/ Catastrophe</i> (eg virtually any major accident not involving UK citizens!)</p>	<p><i>Catastrophic failure with significant impact</i> (eg BA DC10 aircraft crash, UK chemical plant explosion)</p>
	<p>low numbers/ slight injuries</p>	<p><i>"Counted" Accidents</i> (eg road accidents, slipping/ tripping accidents in industry or Asset only accidents)</p>
	<p>low emotive incidents/ little engagement</p>	<p>highly emotive incidents or accidents/ high degree of concern</p>
	<p>Emotive rating ("newsworthiness"!)</p>	

Figure 4. "Hard" (severity) v "Soft" (emotive) classification of accident events.

The emotive axis will influence the Corporate Image and thus the marketing of the organisation's services or products while the actual consequences will impact directly upon costs, financial viability and thus, again, marketing considerations. Thus a "focused" strategy is referenced. Most hazards, thankfully, never become accidents and even fewer hurt or kill people. However, these events will happen and the risk should be estimated and managed in

any organisation. (Reason's (1994) systemic approach to organisational error is most pertinent to this view.)

The costs of accidents have only been publically quantified infrequently. The fire on Piper Alpha (£125M (Financial Times 28.11.94)) is an example of a Catastrophic failure and HSE(1993) reports "Counted" examples. The HSE(1993) reported five cases studies where recorded accident rates and immediate direct costs were monitored:

- **A Construction site of a major civil engineering company building a supermarket.**
87 accidents and £5833 loss per employee year representing 8.5% of the tender price.
- **A Creamery manufacturing dairy products.**
11 accidents and £2886 loss per employee year representing 1.4% of operating costs
- **A Transport company operating a fleet of tankers for the milk marketing board.**
14 accidents and £2446 loss per employee year representing 1.8% of operating costs & 37% of profits.
- **A North Sea oil production platform.**
5 accidents and £17924 loss per employee year representing 14.2% of potential output.

-
- **A NHS Hospital belonging to large metropolitan Health Board.**

7 (non medical accidents and £567 loss per employee year representing 5% of annual running costs)

The level of fines in the West Midlands region for criminal prosecutions under the Health and Safety at Work Etc. Act (1974) is typically between £1000 - £3500 per life and for other injuries about £750 per case (Bergman (1994)). An apparently extreme level of fine of £10,000 (plus £550 costs) was impose upon North Tyneside College after a student cut the tops off two fingers. (Newcastle Evening Chronicle 26.7.94).

In the case of civil cases the range of settlements is also large. The Mountenay (Hazzard) and others v Bernard Mathews) settlements ranged from £400 to £5000 for general damages while £79,000 was awarded for an Inland Revenue typist. (The Guardian 20.12.93) This latter settlement is the largest so far within England and Wales and the recent settlement of £72,000 against Clyde Shaw (a Motherwell Steelmaker) the largest in Scotland (Financial Times 3.9.94).

In all of these reports no details were given as to the proportion of the settlement that was covered by insurance, legal aid, etc. Legal costs and management time will be considerable more than these published sums

and the long term Strategic and Corporate costs will be more difficult to quantify but may ultimately be a bigger threat to the business.

The full costs concerning an accident or other undesirable event can be listed under five headings that will generally be quantifiable by those concerned within the organisation and thus can be used to balance against the cost of the application of ergonomics. It must also be remembered that as British Industry tends to focus on “Core Businesses” then the effect of a particular failure or shortfall can be much greater than if a bigger range of revenue streams were operated. The degree to which these costs or liabilities are covered by insurance is, of course, also significant.

The job, production unit/line direct costs

- Lower output quantities that give rise to increased labour costs.
- Lower output quality involving re-working whenever it is identified, and the risk of customer dissatisfaction.
- Lower output quality and quantity due to “locum”/“stand in” operators replacing those “sick” and temporarily off work. This might show itself as an increase in the variance of quality, possibly subjective.
- Costs associated with the different production rates of injured or replacement workers as well as line inefficiency costs. This is especially important and

obvious if Kanban, Just-in-Time (JIT), MRP, MRPII, etc. methods are used to closely monitor production and either require zero “buffer-stocks” or produce data for the stock value “Tied-up”.

- Increased labour turnover resulting in significant recruitment and training costs as well as line inefficiency costs (including costs of agency staff to “cover”).
- Cost due to damage to plant, work in progress, materials, etc.

The job, production unit/line indirect costs

- The cost of Injury claims ultimately causing increased employer liability insurance premiums. (Most policies were for “an indemnity unlimited in amount” rather than a specific agreed sum but this changed from 1 January 1995 when an ordinary, legally required, limit of £2M per event and £10M total became routine. “Top-up” insurance is obtainable but the premiums will be matched to the insured risk and it is unlikely that the basic insurance premiums will drop in line with the reduced cover provided.
- The cost of Injury claims leading to both direct (eg “sick pay”) and indirect costs (eg management time used to deal with the situation) and ultimately increased insurance premiums. The impact of the financial costs of “sick pay” have, of course, increased since the

responsibility for this largely passed from the State to the organization.

- Costs associated with additional pension payments/lump sum provision for people taking early retirement on “sickness” grounds.
- Reduction in morale and thus the ability to function effectively both at a factory floor and at a plant management level.
- Reduction of the organisation's public image locally affecting recruitment, esteem of staff (including Senior Managers/Directors), etc.
- Administrative costs associated with managing the accident or risk, etc.
- Poor motivation directly increases costs and limits the ability to respond to opportunities (eg staff are less likely to be enthusiastic about additional overtime working).
- Legal costs both for the company and, perhaps, the individual line/factory managers concerned to be blamed for the accident.

Cost associated with the suppliers and customers of the organisation.

- The customers lose supplies or receive them late, perhaps after the main buying period (eg Christmas). The quality might be reduced resulting in additional repair/replacement costs. In the extreme the customer

might have costs associated with the identification and contracting of alternative supplies. A supplier “rescuing” the original company's customer will probably seek to maximise their gain, perhaps by demanding long term contracts are signed.

- The suppliers might find themselves left with materials that are not required and which they are unable to sell elsewhere. This can lead to cash flow problems, especially for small companies. If sales are possible elsewhere then this might enhance the strength of the competition and make future trading more difficult.
- The confidence of the customer and supplier might be reduced for a considerable period of time, way beyond the time taken to settle the initial incident.

Wider company/corporation strategic costs

- The industry wide impact of a poor claims record concerning any significant company because of the suspicion that all plants operating in this field will be a similar risk.
- If poor management is clearly to blame then the Insurance Company might not fully settle the claim in full; Insurance companies only cover unexpected risk!
- Limitation of options on corporate identity coherence. Should companies link all operating units together and, if so, how closely.

- Reduction of the organisation's public image nationally effecting relationships with clients, financial institutions, etc. and thus the share price (shareholder wealth), rates on loans, bonds and derivatives, etc. These can be major “motivators” for senior staff.
- Concerns of major customers that would not wish to be publicly identified as associated with companies that injure or care little about their work-force; Brand and/or Corporate image congruency especially if members of the Investors In People(IIP) programme.
- The Wider effects of image damage influencing the behaviour of market makers, bankers, etc. This could ultimately influence share price (shareholder wealth) and perhaps rates on loans, bonds and derivatives, etc.
- Possible costs and embarrassment of any uninsured Board liability (civil and criminal) and perhaps, although unlikely, the ultimate DTI sanction of removal from the Board.

Wider Societal costs - not usually accepted as the organisation's responsibility

- Costs to those directly involved in the incident - the Dramatis Personae. These costs might be covered by the ultimate legal settlement but this can take several years and, without legal aid or Union backing, it may not be possible to pursue any contested claim.

- Costs to the Kith and Kin of those involved in the incident. These costs might be covered by legal settlement but this can take several years and is, by no means certain.
- Society as a whole will have cost that must be covered by all. These include DSS administrative costs, NHS costs (physical and psychological), loss of income tax, etc.

Conclusion

Ergonomics is of value to business, it does add value to products and services and can significantly reduce the costs associated with their supply. These costs include those associated with the general functioning of the organisation and those, largely uncontrolled costs associated with undesirable events. Thus ergonomists can support both strategies for gaining competitive advantage identified by Porter. However they must improve their skills of quantification and qualification so that the value they add is recognised by business.

Ergonomists are not, generally, trained in corporate financial management or even project appraisal/valuation but they are able to highlight the benefits to be obtained from, and show the costs associated with, their work. We must adopt models to remind ourselves of the need to consider the financial aspects of our work (Figure 5.) and delegate the detail to others. The Ergonomist can, and should, support the organisation's managers to ensure that

a full appraisal is undertaken of the value of ergonomics to the business.

The Specified Problem Boundary
Systems, Investigative, Applicable Ergonomics and organisational
financial appraisal and culture and the interactions.

Musculoskeletal criteria for work-place design
(Anthropometry, Physiology, Biomechanics, etc.)

Personal & Group Attributes
(Owners, Users, Customers, &
Bystanders, etc.)

Environmental, Stressor
Ergonomics (Individually
and in combination)

Information Ergonomics
(Interaction/interface
Ergonomics).

The Wider Systems Level and interactions
Legal, Regulatory, Organisational, Strategic, Corporate, and Cultural.

Figure 5. The Meta Ergonomics - Business Interaction Model.

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