THE ECONOMICS OF INTERFACE DEVELOPMENT

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This paper argues that decision theory can be used to identify different attitudes towards 'usability engineering'. The advocates of formal methods and ethnomethodology argue that initial investments offer substantial benefits to subsequent development. For other groups, high cost techniques are seen to offer few rewards for interface design. The following pages exploit utility curves to represent these different perspectives. The intention is not to map out all of the complex factors that affect human decision making but to focus on the interaction between issues of cost and probability in commercial project management. Decision theory provides analytical techniques that can be applied to the resulting models. In particular, risk preference coefficients are used to explain part of the reluctance to exploit 'advanced' design techniques for human computer interfaces. Later sections exploit the utility curves to identify an agenda for future research in human computer interaction.

Keywords: *decision theory; utility; economics of design.*

1 Introduction

There is an increasing realisation that human factors issues must be considered during the commercial development of computer applications. Hewlett Packard [8], Philips [11], Silicon Graphics [12] have all recruited human computer interaction expertise during the design of their products. In spite of this progress, there seems to be considerable reluctance to exploit many of the approaches that have been proposed by research in this field. Few companies have applied formal modelling techniques [2] or ethnomethodology [4]. This reluctance stems from the high costs and low benefits that are anticipated from these 'advanced' techniques. The following pages exploit the micro economic concept of utility to represent and reason about these attitudes towards the costs and benefits of interface development. Section 2 briefly reviews empirical and theoretical work on utility. It is argued that indifference curves can be used to characterise an interface designer's attitude towards the costs and benefits of development techniques. Unfortunately, it is difficult to validate the results obtained from this approach. Indifference curves are, typically, extracted using an iterative interviewing technique. The preferences expressed during these interviews may not accurately represent an individual's attitudes under the pressures of commercial development. In contrast, section 3 introduces a generic model of utility. This captures the frequently criticised view that interface development is a low cost, low utility process. From this model, it is possible to identify some of the causes of under investment in 'usability engineering'. Section 4 contrasts the low cost model with views that anticipate high levels of utility with the resources that are allocated to interface development. Decision theory provides formal techniques that can be applied to these models. Risk preference coefficients are used to explain part of the reluctance to exploit 'advanced' development techniques. Section 5 uses this analysis to examine ways in which the field of human computer interaction might progress in the next five years. In particular, it is argued that quality assessment procedures are required to promote good practice and increase the anticipated utility of interface development. Low cost techniques must also be developed to increase the commercial exploitation of research in this area.

2 What Is Utility?

'Usability engineering' consumes finite development resources. Money, time and skill are allocated to those activities that are expected to provide the

greatest rewards. If interface design techniques are expected to offer few benefits then relatively few resources will be provided to improve interaction. Conversely, if the anticipated benefits outweigh the costs then more money, time and skill will be allocated to this process. It is, therefore, important to consider the relationship between the resources allocated to interface design and the expected rewards for this activity. In order to do this there must be some means of representing and reasoning about the costs and benefits of development activities. For instance, Mantei and Teorey estimate the dollar savings that improved usability can bring when more people are recruited during user evaluations [9]. There are a number of problems with this approach. It is difficult to assess the monetary value of improved safety and the benefits of increased job satisfaction. In contrast, this paper exploits utility theory to analyse the costs and benefits of interface development. Utility can be thought of as a measure of 'desire' or the capacity of a good or service to satisfy a need. A number of different approaches can be exploited to represent the utility that designers associate with interface development. For instance, March and Simon's satisficing identifies the subjective 'desire' for a good or service by iteratively refining the constraining equations that characterise preferences between development tasks and services [10]. Unfortunately, the difficulty of accurately identifying an individual's preferences has been a common theme of recent research in economics and decision theory [16]. One means of avoiding this problem is to construct high level models of utility that characterise viewpoints that are common to groups of individuals. This approach suffers from a lack of empirical evidence. It is difficult to determine whether such models accurately capture attitudes towards the costs and benefits of interface development. This paper recruits a number of surveys into industrial interface development to avoid such a criticism [1, 3, 14].

3 Under Investment in Interface Development

Dillon, Sweeney and Maguire's recent survey of commercial interface design reported that only nineteen per cent of companies devoted staff and facilities to 'usability engineering' [3]. Bellotti's survey of current design practice cites the common observation that there is "no confidence in HCI as a discipline and no perceived need for it" [1]. Figure 1 represents this attitude; interface design is a low cost process that requires relatively few resources, The marginal utility, or the amount of value associated with an additional unit of resource, has a constantly low value in this model. The resources allocated to interface development provide few rewards. This contrasts with application design which is expected to provide high levels of marginal utility at low levels of absolute expenditure. Designers would only make a minimal allocation to interface development if they held this view of expected utility. Most resources would be directed towards application implementation.

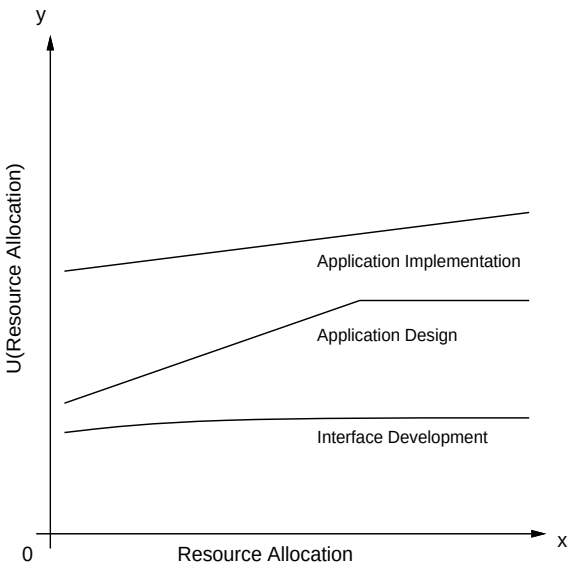

Figure 1: Perceived Utility Of Development Activities

This view can be explained by the problems involved in identifying the benefits of improved usability. Most of these improvements will only be observed after the final release of the product. This indicates that their might be a circular problem. Interface design has a low utility because insufficient funds are being allocated to this development activity. Insufficient funds are being allocated because it is difficult to assess the utility of interface development.

4 High Utility Models

In contrast to the low cost view of the previous section, many 'advanced' techniques require high levels of expenditure in order to be effective. For instance,

formal methods commonly involve the use of discrete maths and logic [5]. Similarly, ethnomethodology and non-intrusive video recordings require considerable skill on the part of the analyst [4]. The advocates of these techniques often assume that there is a high marginal utility for resources allocated to interface design at high levels of expenditure.

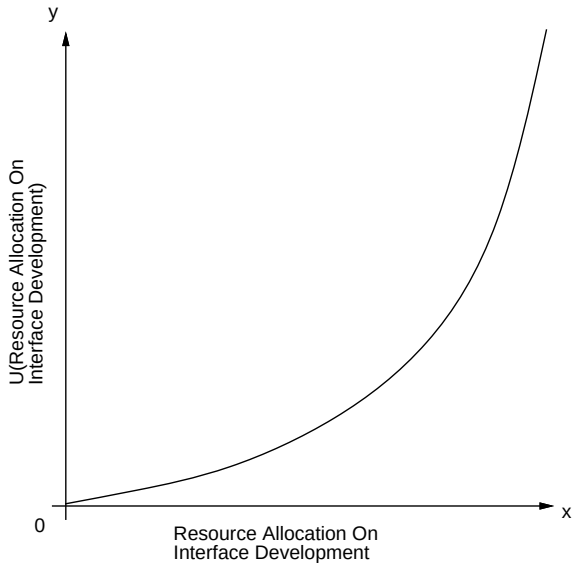

Figure 2: Exponential View Of Interface Development.

Figure 2 represents this view. This high cost, high utility model is appropriate in safety-critical applications [6]. In other industries, high expected costs may dissuade designers from diverting resources towards interface design. Mantei and Teorey estimated that the costs of introducing human factors considerations into the software development process amounted to $128,330 in 1988 [9]. Nielsen observes that "a project manager would discard any attempt at 'usability engineering' in the belief that the project's budget could not bear the cost" [14].

Low cost approaches to 'usability engineering' rely upon the view that there is a high marginal utility for the initial allocation of resources to interface development. For instance, the use of scenarios, pencil and paper mock-ups, questionnaires and informal interviews can quickly yield benefits for designers. The critical point at which resources are anticipated to yield significant benefits occurs at a much lower level than in the exponential model. Figure 3 represents this and also shows that diminishing marginal returns can be expected at high levels of resource allocation. This reflects the view that additional resources do not always yield an increasing level of utility. For instance, increasing the size of an interface design team does not always increase the effectiveness of their work. Groups can be burdened by the additional demands of training new members. In these circumstances, the allocation of additional resources will result in smaller increases in expected utility.

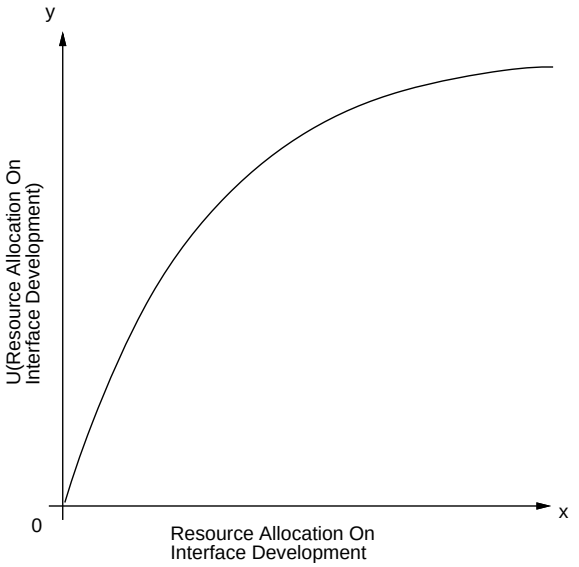

Figure 3: Low Cost View Of Interface Development.

The utility curve shown in figure 3 has a number of important consequences for the future of HCI if it accurately reflects commercial attitudes. Sommerville, Rodden, Sawyer and Bentley have investigated the technical problems of of exploiting ethnomethodology during systems development [17]. They conclude that "it will be many years before the participation of a sociologist in a requirements team is normal practice". Our analysis suggests that even if the technical problems can be solved, there remains the problem of altering attitudes. Developers must be convinced that the costs associated with these techniques are justified by their potential benefits over low cost approaches.

5 Altering Attitudes

Von Neumann and Morganstern created the foundations for modern decision theory when they argued that decisions are made by assessing both the potential benefits of services and the likelihood that a particular resource allocation will actually deliver

those services [13]. In terms of this paper, developers must consider the likelihood that a particular level of investment in interface development will actually result in the anticipated benefits. Managerial pressures or changing working practices may jeopardise the rewards that are anticipated from an initial resource allocation. This analysis can be taken a stage further; decision theory suggests that utility curves can be used to identify risk preference and aversion. The risk preference coefficient of a utility curve is defined to be the second derivative divided by the first [16]. The exponential model, of figure 2, represents an inclination to take risks. Rather than invest the large amounts of resources that are expected to provide high levels of utility, developers might be tempted to gamble by reducing their levels of expenditure. The rise in marginal utility in the low cost approach, of figure 3, is less concave than the exponential model. From this it follows that low cost development techniques will not only be justified in terms of the absolute expenditure required for interface development but they will also reduce developers' inclination to take risks with that expenditure.

Regulation and legislation can also be used to combat under-investment in interface design. Following the Presidential investigation into the Three Mile Island accident, the United States' Nuclear Regulatory Commission required that operators should not be forced to immediately intervene during an emergency [15]. Designers were required to demonstrate that their interfaces provided time for reflection about critical decisions. This ensured that low levels of expenditure on interface development resulted in very low levels of utility; proposed systems were rejected as unsafe. Figure 4 illustrates the way in which regulatory authorities affect developers' attitudes towards HCI. Small scale expenditure on interface development is not anticipated to provide any benefits; it will not satisfy the quality assessment procedures imposed by external authorities. This breaks the cycle of under-investment. Positive marginal returns yield a rapid increase in utility. Eventually, diminishing marginal returns set in. At this point, the regulatory and legislative authorities are considered likely to accept the system. There is evidence to suggest that regulation is already altering expected utility in the manner suggested by figure 4. There has been an increasing interest in the development of user interface standards from organisations such as the International Standards Organisation. It is important to note that standards need not be imposed by external authorities. Several companies are developing in-house criteria for interface design. If interfaces do not meet the standards imposed by these documents then they are returned for further consideration. This forces designers to provide additional resources for interface development. Many problems frustrate the successful application of these techniques. Several standards have been criticised as internally and externally inconsistent [14]. Others are ambiguous at the level of detail required by designers; the European Council directive 90/270/EEC includes the requirement that "software must be easy to use". This paradoxically creates 'usability' problems when designer attempt to apply these 'usability' criteria. A further problem is that the techniques exploited by quality assessment groups often seem to be ad hoc and subjective. There seem to wide differences in the methods used for empirical evaluations [1]. Peer reviews can be affected by 'political' pressures from within an organisation. More research is urgently needed into the organisational problems of quality assessment for human computer interfaces. Lee's quality circles for software engineering provides a useful starting point for this research [7].

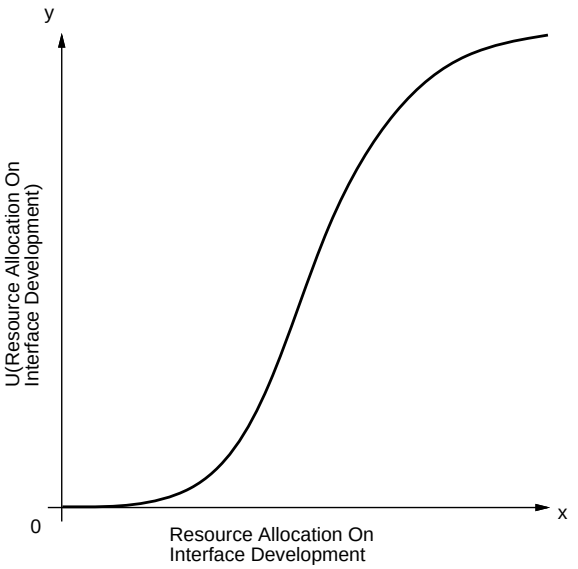

Figure 4: The Impact Of Legislation And Regulation.

6 Conclusion

This paper has argued that the expected utility of interface development affects the level of resources that are allocated to this activity. Three different views have been identified: the traditional; the exponential and the low cost. The traditional approach represents interface development as a low cost process that requires relatively few resources. This perspective leads to under-investment in the design of human computer interfaces. Additional resources are sucked into later stages of development to repair deficiencies that might have been identified earlier in the development of an application. In contrast, the exponential model represents the view that additional expenditure on interface development is expected to bring increased benefits at high levels of resource allocation. Many of the advanced techniques that are being proposed require significant resources if they are to be effective. Finally, this model has been contrasted with the low cost utility curve. High cost techniques are anticipated to offer few benefits over an initial allocation on interface development.

These utility models suggest a number of future directions for the field of HCI. The first of these has been identified from the formal relationship between utility and risk in decision theory. The risk preference coefficient of a utility curve is defined to be the second derivative divided by the first. The exponential model represents an inclination to take risks with the allocation of resources towards interface development. Rather than invest the large amounts of resources that are expected to provide high levels of utility, developers might be tempted to gamble by reducing their levels of expenditure. This contrasts with the low cost model that is characteristic of risk aversion. The high utility of relatively low levels of expenditure will encourage developers not to risk the allocation of resources to this development activity. From this it follows that developers must be provided with low cost techniques for interface design. This is not a novel observation; it lies behind research into cost effective elicitation techniques and work into tool support for formal modelling. The second direction for future work in HCI builds upon quality assessment procedures for interface design. Monitoring groups can be used to ensure that low levels of expenditure result in very low levels of utility; proposed systems will be rejected. This approach can only be successful if developers are provided with techniques that provide feedback on the quality of designs for human computer interfaces. Recent investigations suggest that ad hoc management techniques and unstructured walkthroughs have a number of limitations [7]. More research is urgently needed into into the organisational problems of quality assessment for 'usability engineering'.

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