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THE ECONOMICS OF TRAINING IN COMMERCIAL COMPUTING IN SPAIN

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ABSTRACT

This work studies how firms staff a new and changing industry in a rapidly developing economy.

If, according to Spanish computer professionals, trained manpower is such a binding constraint, how is it that the installation of computers has grown at an average annual rate of more than 20% since the 1960's?

I show that the training issue underlying the alleged manpower shortage is part of the problem of choosing a computer technology. Training is a constraint of choice of technique. Thus, training cannot be dealt with independently from technology.

The analysis of technology under uncertainty and imperfect information cannot be adequately handled with standard tools like the micro-production function. Thus, full information and certainty are substituted by: (1) uncertainty of outcomes (2) "trial-and-error" decision-making; and (3) individuals maximize their behaviour by conjecturing about uncertain outcomes and therefore, certainty in maximization is discarded.

The problem-solving nature of working activities provides the link between skills and training. This enables me to study: (1) the emergence, and specialization, of formal training; (2) the signaling value of the content of training as reflected in the similarity between the problems solved on the job and during the training period; (3) training as a decision variable in the choice of technique; and (4) the ambiguity of manpower shortages.

The ambiguity of manpower shortages is mainly due to the scope for choice of technique and redesign: output and physical capital

specifications, training, job redesign, hiring, promotion and wages, are combined in different proportions by decision-makers. When this flexibility in labour and tasks design is compounded by uncertainty and novelty, manpower planning can hardly be seen as an improvement to the outcomes produced by the market.

My approach to training provides an efficient framework for the study of issues raised in this work about the theory of training and the understanding of Spanish commercial computing. At the policy level I show that however unwarranted manpower planning appears to be: (i) governments cannot escape having a policy in new technologies, even if only by omission; and (2) government policies in new technologies are inevitably tentative.

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CONTENTS

Chapter 1

INTRODUCTION

1.1. Scope and Purpose

The central problem of this thesis is the alleged shortage of well-qualified specialists in commercial computing in Spain. Since training is the binding constraint, I focus on the analysis of the demand for and supply of training in this rapidly growing and continuously changing industry. The theoretical issues are: (1) the influence of uncertainty and costly information on training choices; (2) the interaction between the market for computers and the market for computer specialists, that is, the interaction between choice-of-technique and choice-of-employment; and (3) the signaling value of training and certification.

Starting from the concept of "skill", an integrated analysis of training and manpower shortages in Spanish commercial computing is developed. The identification of skills as problem-solving hopes to provide the foundation for an economically significant explanation of the concept of training. The proposed specification of skill content is used to show how training emerges and evolves in new tasks, and how it can be supplied by training-on-the-job and off-the-job. Choice among technologies determines both the characteristics of training and the number of trained specialists over time. Thus, <u>the solution of the problem of manpower shortages is at the same time the solution of the problem of choosing a computer technology</u>.

Having outlined the main theoretical questions, I turn to the empirical relevance, and policy implications, of the study of training in commercial computing in Spain. Since the 1960's electronic data processing has grown at an extremely high rate in Spain in the context of a high overall rate of economic growth. This case study furnishes an illustration of how a developing country should staff new, and continuously changing, industries. Additionally, the analysis of the computer growth in Spain may be relevant for the analysis of other rapidly growing sectors in the Spanish economy that use advanced technologies.

There is a widespread belief in Spain that there has been a persistent shortage of "competent" specialists ever since commercial computing started in the early 1960's. According to most decision-makers in commercial computing, the inferred market failure can only be overcome by government intervention, that is, by manpower planning. However, this policy alternative is not theoretically warranted. Neither perfect competition, nor manpower planning, are well suited to the following characteristics of commercial computing: (1) uncertainty and, costly, imperfect information; (2) technique, job design, and training are policy variables; and (3) inputs and outputs specifications are heterogeneous.

I argue that in the early stages of the introduction of a new set of skills, the market plays a limited role, government policies are of necessity tentative, and decisions taken by employers and employees are highly influenced by the characteristics of internal labour markets, because with a new and rapidly changing technology, the information generated by the market is very unreliable. That is why I look at (a) the internal labour markets of firms to discover the different ways in which qualified computer specialists are produced; and (b) the expanding role of the external labour market as the level of standardization of the new technology and training increases over time.

1.2 Analysis

According to standard neoclassical labour theory, manpower shortages may be overcome in the short run by higher wages and by lower hiring and promotion standards. In the long run, the problem is solved by investing in training. Thus, persistent manpower shortages cannot in principle take place in a competitive market. However, the conventional view among Spanish computer professionals seems to favour the belief that there exists a chronic shortage of highly qualified specialists in commercial computing. In addition, they tend to support manpower planning as a remedy for market failure in training enough specialists.

It is my contention that the conflict between what the outlined theory predicts and the widely held view mentioned above, cannot be resolved by confining the analysis to: (1) producing an operative definition of manpower shortage; and (2) comparing the relative adequacy of perfect competition and manpower planning as a means of overcoming labour shortages. My contention rests on the decisive role played by novelty and information acquisition in new technologies and their logical incompatibility with perfect competition and manpower planning.

In new and rapidly evolving technologies, the generation of genuinely new knowledge profoundly affects the conjectural nature of economic relationships and decision-making, since knowledge is inescapably incomplete. Choice of technique under uncertainty and imperfect knowledge of the range of technical possibilities cannot be adequately handled with scalar measurements founded on an objective exchange-value. Nor can inputs be considered homogeneous, since inputs embodying different technological vintages will differ in their productive capabilities. But, even more damaging technological novelty takes place under uncertainty, which implies that the exchange-value of assets embodying new know-how depend on expectations and, therefore, their values are speculative and inherently unstable.

What uncertainty and imperfect information does to economic values has to be compounded with the technological and institutional mutability of economic assets that is conjectured, and eventually manipulated by decision-makers. That is why micro-economic production functions mis-specify the economics of technological relationships. The concept of micro-production function fails to account for novelty and costly information and it assumes: (1) full knowledge of unambiguously specified input-output relationships; and (2) technological relationships as scalars that are manipulated by decision-makers via changes in factor proportions.

In other words due to novelty and information costs, economic relationships are not unqualifiedly objective, nor are they technologically certain and unambiguous. Thereby Pareto optimality considerations are beside the point.

Thus, I do not analyze the alleged manpower shortage in Spanish commercial computing by attempting to produce a description of the conditions that would produce Pareto optimality or even a second-best solution. Such an undertaking would assume away novelty, uncertainty, and the intrinsic ambiguities of investments in new technologies.

Instead, I incorporate these issues into the study of the interaction between choice of technique and training, under uncertainty and costly information.

As the concepts of manpower shortage, manpower planning and competition are used in a variety of ways in the economic literature, I postpone the necessary clarifications until these concepts enter the mainstream of the argument. In so doing I expect to provide an empirically more useful discussion of the issues raised. The immediate task is to present the main threads of the analysis.

Because of novelty in choice of technique I assume uncertainty of outcomes and discard Pareto optimality. As for the behaviour of economic agents I assume maximizing behaviour, without implying certainty in maximization. Decision-makers follow a trial-and-error approach to maximization: they conjecture what is likely to be the best possible outcome, bearing in mind that the uncertainty of outcomes makes their conjectures tentative.

This is not a departure from standard theory, but a logical extension of the role which uncertainty plays in standard economic analysis since F.Knight introduced the classic distinction between risk and uncertainty. This meant that events that can be insured against, that is, risky outcomes, can easily be assimilated to non-risky outcomes, since it is possible to form a certainty equivalent of uncertain outcomes that refer to realities that had already taken place in the past. Uncertainty however, cannot be insured against as it refers to something that has not been experienced before and therefore actuarial calculus cannot be used. According to Knight profits are uncertain and profits have always been part of standard theory.

Following Knight's classic dichotomy I argue that choice of technique and training are un-insurable risks due to novelty. Thus, uncertainty is not confined to final outcomes -- profits or losses -- of an investment decision; uncertainty is an inescapable ingredient of decision-making. Behaviour in new technologies always takes place under uncertainty.

In other words, I assume that economic agents maximize their behaviour by conjectuting about uncertain outcomes. But, of course, if decision-makers know that outcomes are uncertain, they are choosing under uncertainty. So, what I do is nothing more than explicate that Knight's concept of profit implies that behaviour always takes place under uncertainty. However, this is not to say that risk, as defined by Knight is a false category. The paradoxical result has to do with the distinction between risk as a category that deals with groups of events and the uncertainty of a single outcome or decision. In short, my behavioural assuptions do not need to rely on novelty. They are logical implication of defining profit as an uncertain outcome. Novelty only increases the degree of uncertainty.

Employers and employees in commercial computing are severely constrained by uncertainty and costly information. <u>Their choices are tentative and interdependent</u>. Feed-backs from other decision-makers, actual performance of production processes, and novelty lead to piece-meal, tentative, decision-making behaviour. Technique is not a parameter. Inputs and outputs specifications, training, job searching, hiring, and promotion policies are imperfectly understood variables that are modified at a cost, whenever decision-makers conjecture that the current combination can be made more cost-effective. That is, what matters to decision-makers is producing an output with given specifications as efficiently as possible, which amounts to choosing a production process with specifications that are deemed to result in a more profitable business outcome.

In this context, I begin with the concepts of training and skill, and show the need to consider technology. The micro-production function is rejected on the grounds that it assumes full information and thereby is incompatible with novelty and training. In order to deal with technique in a world of uncertainty and costly information, factor substitution and changes brought about by costless technology are replaced by the dichotomy between flexibility in facing uncertainty and standardization to maximize physical output for a well-defined set of constraints. Thus, while the spurious concept of costless shifts of the range of technological possibilities is abandoned, the concept of substitution gains in scope and empirical relevance. Factor substitution materializes the choices on the conjectured trade-offs between flexibility and standardization under uncertainty.

After analysing production under uncertainty and costly information, I specify skill content as problem-solving. Then, I conjecture how training specialization and the emergence of formal training take place. I also show how proficiency in the command of skills and the speed in acquiring relevant abilities can be enhanced by certificates awarded to those that undergo off-the-job training. With this preliminary work, I develop the analysis of the behaviour of decision-makers in commercial computing. That is, I discuss the characteristics of the demand for and the supply of training from the standpoint of the decision-makers involved. By discussing training choices, manpower shortages are set in perspective, as training is an unavoidable constraint in staffing new technologies that require sophisticated skills.

With the discussion of the demand and supply of computer specialists, and the critical appraisal of the concept of manpower shortages, the relative efficacy of market forces and manpower planning is dealt with. However, it is not until the last chapter that policy issues are explicitly evaluated.

1.3 Methodology and Data

As I show in this research, published information on computer specialists is unreliable. The heterogeneity of occupational classifications, uncertainty, information costs and risk attitudes among employers and employees play important roles in commercial computing. In addition, information on the Spanish labour market is very limited and, often, of dubious validity, since most classifications are based on socio-economic groups. Furthermore, the educational composition of the labour force and its occupational distribution have undergone profound changes during the last fifteen years.

This explains why the information obtained interviewing 107 individuals working in commercial computing is the empirical cornerstone of this investigation. The interviews were geared towards the discovery of the economically relevant dimensions of training and their logical relationships. A first approximation to the problem of training in computing indicated that training, occupational categories, educational qualitifications and specific skills are the result of a combination of forces that are hardly understood by employers and employees in computing.

Rules of thumb, trial-and-error procedures, and observation of "what the neighbour does" appear to be behind many of the things taking place in computing.

Though this evidence cannot be easily interpreted, it is nonetheless reasonable to infer that occupational classifications are heterogeneous. The very concept of occupational classification, and the role of job design and training, have to be reappraised.

As a result of these considerations, the following criteria for selecting interviewees were developed. First, existing regional differences had to be taken into account. For reasons of background information, and of convenience, four areas were selected: Andalusia, the Basque Country, Castilla la Nueva and Catalonia.

Second, the investigation was confined to those tasks performed by highly qualified manpower. Activities more akin to conventional office work were left out, for it appeared that training problems would be very different between the two groups.

Third, people with different backgrounds were interviewed because of the non-existence of a generally accepted educational background, or work experience, demanded by employers. Entry is open to all, even if this is not true of all firms. A trainee starting with a very simple task can end up doing the most sophisticated tasks, such as software programming. Interviewing some of those who had gone through this process had to shed light on training, career patterns, the scope for choice and the opportunity cost involved. Finally, I assumed that differences in experience would be frequently related to the kind of employer(s) the interviewee had; whether the employer was a computer manufacturer, a service bureaux or a computer user, was likely to influence training attitudes, career patterns, etc.

On average, interviews lasted between two and three hours, each person being interviewed only once. However, the first few interviewees were always met twice or more, as the initial range of questions was very broad in order to let interviewees contribute to the identification of relevant issues.

In addition, those who, for one reason or another, did not exhaust their information potential in one interview, were met twice or more. The interviews were basically open-ended. Each interviewee was asked to give his own profile, to describe his installation and to name, and analyse the problems he considered to be most relevant to computing or to computer professionals -- specially those referring to training and the job, that is, salaries, promotion, mobility, entry barriers, etc.

In order to obtain a sample of computer specialists that would meet the criteria specified above each interviewee was asked for names of colleagues who could, in their opinion, contribute in some way to the research. From these suggestions I decided, by a rule of thumb, how many of each "type" were going to be interviewed.

The analysis of the information gathered shows that the backgrounds of those interviewed help in understanding the issues posited in this thesis. And it is to the analytical foundations of such interpretation that Chapter 2 is devoted. The theoretical framework developed in Chapter 2 is applied to the analysis of training in commercial computing in Chapter 3. Chapter 4 follows with a predominantly empirical study of computer training in Spain. Chapter 5 furthers the empirical investigation started in the previous chapter, but it concentrates on Catalonia, as this market, although it is not the largest in Spain, has the richest background information and opens the way to the discussion of regional differences.

Finally, Chapter 6 summarizes the analysis and empirical research developed in this thesis and offers a discussion of the main conclusions and policy implications.

Chapter 2

TRAINING IN A NEW INDUSTRIAL SKILL

2.1 Introduction

In this chapter I analyse training investments in new skills. A starting point is provided by the concept of skill. The specification of skills as types of problem solving, and the economics of flexibility and standardization under uncertainty, are relevant in explaining: (1) choice of technique and job design as policy variables, and thereby the inherent ambiguity of occupational groups, elasticities of substitution, and manpower shortages; (2) the scope for training and the emergence of formal training; and (3) the screening and signaling value of formal training.

Although training tends to be investigated in the context of the labour market, I show that training issues extend beyond the conventional boundaries of labour economics. Training is not only a labour demand issue, nor is it exhausted by adding labour supply considerations: staffing and training decisions are components of choices of technique. Additionally, training choices are not independent from earnings and non-pecuniary considerations. That is why I begin with Becker's concept of training[1] and conclude that Thurow's "job-competition" model[2] is more relevant to training in new technologies.

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1 Gary S.Becker, Human Capital A Theoretical and Empirical Analysis with Reference to Education 2nd edition (New York: Columbia University Press 1974) chapter 1.

2 Lester C.Thurow, "Measuring the Economic Benefits of Education" in Higher Education and the Labour Market, Margaret S.Gordon ed., (New York: McGraw-Hill Book company, 1974): p.389.

2.2 Training and the Concept of Skill

Training, from an economic standpoint, consists of allocating resources to the acquisition of productive skills. Such a definition results in the asking of what are productive skills. The conventional answer is: those abilities that increase the output yield when they are applied to production by labour. Considering that there are many occupational groups performing different tasks, the connection between production skills, tasks, and training must be analyzed; a pertinent question is: do these different tasks require different skills?

The classic economic classification of skills is Becker's; he divides skills into general and specific, depending on their inter-firm mobility. However, the following ambiguity is noticed: are skills intrinsically general or specific, i.e. does technology determine their character, or do they partly depend on the structure of the market.? For as Gary S.Becker says:

> "Completely general training increases the marginal productivity of trainees by exactly the same amount in the firms providing the training as in other firms." ... "Training that increases productivity more in firms providing it will be called specific training".[1]

But, as Richard Oatey remarks:

> "...a useful distinction can be made between the generality of of the skills (defined with respect to the content of training), and the generality of the investment (defined with respect to the mobility of the trainees)"[2]

The ambivalence of the distinction between general and specific skills is particularly noticeable in new tasks. The labour market cannot determine the degree of generality of a new skill independently of the degree

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[1] Becker, op. cit. p.26

[2] "The Economics of Training with Respect to the Firm". British Journal of Industrial Relations, 93 (March 1970): 15

of "technical" similarity with existing skills, since the relative sub-stitutability of skills is the characteristic that differentiates skills from an economic viewpoint. In other words, an economically relevant taxonomy of skills has to study labour mobility and the technology or content of the tasks performed; for they will show the relative substitutability or complementarity of each skill and thereby help to identify the opportunity cost of obtaining and using different skill mixes.

When technological considerations are fundamental, how can an economist approach technology? Under full information the concept of micro-production function may be the starting point, since it is the bridge between resource allocation and technology. Decision makers combine input flows to produce an output flow constrained by relative prices and technology. From the range of feasible combinations of inputs, the most efficient combination is chosen, to be altered only in response to changes in relative prices and "costless"technical progress. Changes in the demand for output would also affect the design of theproduction process if there were returns to scale.

However, the distinction between costly factor substitution and costless shifts of the production possibilities is empirically false and analytically misleading. To begin with, there is no such thing as costless technology. The acquisition of information is always costly, even when it is freely available, because technical change involves a choice to learn about a technology and therefore an opportunity cost is incurred. Besides, time, and usually other resources, must be allocated in proportion to the amount of information acquired.

Moreover, acquisition of information and training are inconsistent with certainty or full information. Those who have full information cannot gain further knowledge and thereby, there cannot be scope for training. In addition, training involves novelty and consequently uncertainty. Therefore, the micro-production function is not an adequate tool for the analysis of training since it assumes perfect knowledge of the range of feasible production possibilities.

Putting it differently, the analytically substantive issue is not the difference between costly and costless know-how; choosing what, how, and how much to learn is always fraught with uncertainties and alternative courses of actions are foregone. Thereby an opportunity cost cannot be avoided. The cost of information acquisition to an economic agent - training for example - is always positive because of uncertainty, inputs used, and foregone alternatives that go with choosing to acquire know-how. Or, using a different classification: some assets have no direct cost (they are freely available) but all assets have indirect costs for the asset holder.

This section goes beyond disputing certainty, continuity, and costless aspects of technical change as defined in micro-production functions. Information acquisition, be it technical know-how or training, is the result of choices under uncertainty. Decision-makers know that outcomes are uncertain and they choose following a tentative trial-and-error method. They do not give up maximization, that is, trying to get the conjectured best possible outcome, though they are aware of the uncertainty that surrounds their choices and the resulting outcomes.

The implications for the analysis of training are far-reaching. Training is not confined to the labour market; it is a constraint of choice of technique and technical progress under uncertainty. Additionally, as I show in sections 2.9 and 2.10, this also affects the analysis of manpower shortages. Finally, in chapter 6, I show that manpower planning is not necessarily better than market forces in the provision of trained manpower because manpower planning cannot take place independently from technological planning which is inevitably conjectural due to novelty.

Hereafter, I assume that technological change takes place under unavoidable uncertainty. Decision-makers conjecture about changes in technology: they assume that <u>technological forecasting cannot foresee with certainty</u>: (1) novelty; (2) the uncertain evolution of relative scarcities as reflected in demand and supply changes; and (3) how economic agents will react to the imperfectly known changes in technology. In other words, I hold a view of technical change that assumes both induced and autonomous technical change, since markets prices and novelty interact with one another.

What I conjecture about how technical change takes place can be applied to the theories that explain how technical change materializes, particularly to the embodied and disembodied views of technical change. Technical change materialises in physical and human capital as, say, machinery and training, but the future exchange-value and potential for further improvements for a given technological design ("putty-clay models") cannot be found in the current exchange-value of the assets involved or in their current technological specification. Thus, two recurrent themes in this thesis are: (a) the inherent malleability of technology and the uncertain future of technology due to novelty; and (b) changes in scarcities and the volatile nature of decision-makers conjectures about the future.

In short the analysis in this section shows that: (1) the allocation of resources to training always concerns costly factor substitution; (2) choice of technique and training are unavoidably interrelated: the latter being a constraint of the former; and (3) the existence of training is logically incompatible with the micro-production function. Thus armed, the next section fills the content of the empty box of training and shows what sort of production process can offer opportunities for training.

2.3 Skill Content: Problem Solving

Production always involves problem solving: the choice of a specification for the production process, inputs and outputs. The production process, technology for short, is never a datum. An efficient design of a production process is only "technically optimal" in so far as it offers the largest possible output for a given product specification and for a given cost constraint. "Most efficient" and "technically optimal" designs do not exist in a world of imperfect knowledge (costly information) and uncertainty. The degree of efficiency, economic or technological, attained is influenced by the amount of resources allocated to improve the understanding (and training) of a technology -- as shown in the following pages and corroborated by empirical evidence presented in Chapters 3, 4 and 5. Therefore, technical specifications are not invariants, but parameters that can be altered at a cost.

In production, problem solving takes place, at least, when the individual chooses the production process: the specification of tasks that will produce an output with a given characteristic and for a given budget constraint. The first unit of output may, or may not, meet the technical and cost specifications of demand, and the producer can invest in finding out whether a more efficient production process, and output with different specifications, or both, would be more cost-effective. Such an effort involves problem solving too. Since the starting of a production process can be viewed as a type of change in production; in general, changes in the production process, or in output design, always involve problem solving, that is, learning is a consequence of a choice and not the result of technical imperatives.

It might be argued, however, that a man because of experience cannot avoid realising that a production process, or parts thereof, can be improved, or, more generally changed, and hence, he cannot avoid learning. Awareness of possibilities for change is not the same as knowledge of alternatives that actually work and are cost-effective. The latter requires experimentation with the production process. In other words, there is a range of possibilities as to how production and learning are combined. Or, to use Popper's words:

> "There is no such thing as passive experience; no passively impressed association of impressed ideas. Experience is the result of active exploration by the organism, of the search of regularities and invariants. There is no such thing as a perception except in the context of interests and expectations, and hence of regularities or 'laws"."[1]

The alleged technical uniqueness of the learning option, or its being jointly offered with a work option, do not affect the above reasoning. Even if a specific type of knowledge could only be obtained in one way,[2] the individual who chooses it is always foregoing the economic

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[1] Karl R.Popper, An Intellectual Autobiography. Unended Quest (Glasgow: Fontana/Collins, 1976), p.52.

[2] However this is not likely to be empirically so. And that is why I prefer to subscribe the more flexible view argued by Popper:

> "It is the problem which challenges us to learn; to advance our knowledge; to experiment, and to observe: ... Yet every worth-new theory raises new problems; problems of reconciliation..."

Karl R.Popper, Conjectures and Refutations. The Growth of Scientific Knowledge (London: Routledge and Kegan Paul, 1963). p.222

value of other learning options. As for the second consideration, it must be said that the joint supply does not necessarily entail supply in fixed proportions; there is a trade-off between work and the amount of learning offered that can be manipulated via job design, and captured by the employee, when the redesign takes place on the firm where he is currently working, or via a change of employer.[1]

Even a fixed-coefficient production function leaves room for learning from working experience, as the mere consideration of the possibility of (not) substituting such production process for a different one involves a decision on (not) reallocating resources; and the problem-solving involved is not economically different from the one encountered in a variable coefficient production function; in both cases learning depends on a choice.

Therefore, it can be concluded that problem solving is what fills the content of the training black box. This general dimension of training is to be complemented by a more specific analysis leading to a taxonomy of skills in the hope of shedding light on the ambiguity found in Becker's distinction between general and specific training. However, before doing so, uncertainty is brought into the analysis since the uncertain character of the future influences choices in production and hence the scope for training choices.

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1 James G.Scoville brings this out in his analysis of the supply of job types, work-related training, and decision-makers preferences among these options. Manpower and Occupational Analysis: Concepts and Measurements (Lexington, Mass: Lexington Books, DC Heath and Company 1972), chapter 3. In short, the acquisition of productive knowledge always involves a choice between two, or several, learning options, and, in consequence costless training (learning-by-doing) does not exist.

2.4 Standardization and Flexibility under Uncertainty

Division of labour is efficient to the extent that it reduces the amount of resources per unit of output of given characteristics. This is usually achieved in a gradual process of standardization of the production process, and consequently, it diminishes the potential for problem solving.

More specifically, a new technological design: (i) is unambiguously defined in those interfaces between components that are fully-specified; (ii) allows many degrees of freedom in the "man-machine" interfaces, since the latter are those which cannot be fully specified, either because they are poorly understood or are much affected by uncertainty; and (iii) is ambiguously defined in those interfaces among physical assets that are imperfectly understood.

However, there is no such thing as a technically optimal standardization in absolute terms. The degree of standardization depends on output specifications, and on the inputs available, and they are ultimately constrained by uncertainty and economic considerations.

Under uncertainty, standardization (fixed coefficients) is not efficient to the extent that it reduces the scope for adjustment to change -- it becomes costlier.[1] So, under uncertainty, flexibility in the production process, and hence problem-solving abilities, can be an economic asset. These features of the production process are assymetrically reflected as inputs. Thus, whereas fixed coefficients are found in

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[1] Albert Gailord Hart, Anticipations, Uncertainty and Dynamic Planning (New York: Augustus M.Kelly, 1951), p.55

physical equipment, human capital assets have many degrees of freedom, and that is what enables manpower to produce and adapt to uncertain changes by means of problem-solving.[1]

A production system, or a subsystem thereof, always faces an opportunity cost that can be defined in terms of a trade-off between the economic value of flexibility, as a proxy for technology that is effieient under uncertainty, and the economic value of standardization, as a proxy for a technology that produces under conditions of certainty. The efficient dichotomy in production is not substitution vs. shifts in the production function, but <u>standardization as opposed to flexibility</u> -- or reducing the physical amount of output produced for a given set of constraints vs. reducing the possible cost of adapting to uncertain change.

Thus I conclude that uncertainty is relevant to the analysis of production possibilities and their cost-effectiveness. This has important implications for training. The study of these influences opens with a discussion of the role of uncertainty in the development of formal training, that is, training which is not produced as a joint output of a working activity.

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[1] As Nathan Rosenberg says: "While the structure of the social division of labour becomes more complex, the individual worker's role becomes more simple. In the extreme case, and in contemporary jargon, the individual worker becomes the cheapest non-linear servo-mechanism", 'Adam Smith on the Division of Labour: Two Views or One?' <u>Economica</u> n.s., 32 (May 1965): 135.

2.5 Uncertainty and the Emergence of Formal Training

To the extent that the difficulties solved in doing an activity can be classified into homogeneous groups, a typology of production problems is likely to be developed by the problem-solver since it is efficient to copy the process whenever the same problem arises.

The typification of problems -- the ppecification of functional relationships among the variables involved -- is what makes formal training possible. For whereas training, as a joint product with work, does not imply an explicit definition of the functional relationships of the task or the problem to be solved, formal training can only take place if the functional relationships of the tasks to be performed in a job have been made explicit, though it need not be in a systematically logical way. That is why formal training is often defined by its not being offered jointly with work activities, rather than by the type of supplier.

The emergence of formal training is likely to coincide with the relative loss of preponderance of training on the job because the development of formal training is bound to coincide with the standardization of the production process.[1] The formalization of relationship among

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1 The analysis of the emergence of formal training has not received much study by economists. What probably comes closest to it are comments on substitutability and complementarity between schools and firms in the provision of training. Becker, Human Capital, pp. 29-30 and Bowman "From Guilds to Infant Training Industries", Education and Economic Development, ed. C.A.Anderson and M.J.Bowman (Chicago: Aldine, 1965) pp.101-102.

G.S.Becker is not particularly rigorous in this issue. First he cites among others, the construction industry as an example of how some training "is still best given on the job; an unfortunate example since it is well-known that unions in this U.S.industry are engaged in many restrictive practices. Later on, he states that the "complementarity elements between firms and school depend in part on the amount of formalized knowledge available". Finally, he states that: "training in a new industrial skill is usually first given on the job since firms tend to be the first to be aware of its value, but as demand develops, some of the training shifts to school."

Obviously, these statements tell very little about complementarity and substitutability between training-on-the-job and formal training. Nor does it help in understanding why different skills, new or old, have reached different levels of training formalization.

variables will also be used to production-process designers to obtain more efficient combinations, which, in part, will take the form of substitution of physical capital for labour, as the former tends to be more efficient in well-specified relationships (routine tasks).

If the emergence of formal training depends on the specification of the relationships between the set of variables that define the task performed, what requires an understanding is the different level of formalization among productive skills. The explanation I offer is in terms of uncertainty and degrees of freedom.

Production requires the handling of three types of information that lead to three different types of problem-solving activities: (1) the range of options known to the decision maker, what can be done; (2) the relative cost-effectiveness of each alternative, how can it be done; and (3) the economic value of options under uncertainty, what must be done.

In real life such neat differences do not exist. Nor do people specialize in only one of them; for often they are obtained as joined products, though not necessarily in fixed proportions. As Popper states:

> "Disciplines are distinguished partly for historical reasons and reasons of administrative convenience (such as the organization of appointments), and partly because the theories which we construct to solve our problems have a tendency to grow into unified systems. But all this classification and distinction is a comparatively unimportant and superficial affair. We are not students of some subject matter but students of problems. And problems may cut across the borders of any subject matter or discipline"[1]

Nevertheless, I have chosen this classification because it is analytically efficient. It improves the understanding of the distinction between general and specific training by providing a classification of training according to the kinds of problems solved. The economic substitutability, or generality of formal training, is found in the type(s)

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1 Popper Conjectures and Refutations, p.67.

of problem solving practised at the training place. The generality of formal training depends, therefore, on how widespread is the application of a type of problem solving in the different areas of production. Obviously legislation and internal labour markets can influence this divide, for they affect the opportunity costs, and the relative scarcity, of a given type of training.

The first type is concerned with the ability to generate information: to acquire knowledge relevant to the purpose at hand. The second type refers to the ability to use the stock of knowledge to arrive at a solution of a problem under a given set of economic and technical constraints. The third concentrates on decision-making under uncertainty: choices that follow from a qualitative assessment of alternatives in a context of imperfect information and uncertainty.

Formal training is likely to develop among tasks of type (2) due to their low level of uncertainty and to the possibility of obtaining precise trade-offs among the variables involved, thereby making modelling a relatively efficient alternative. Given a set of resources, a production design that satisfies the economic and technical constraints can be found. Engineering tasks, manual or otherwise, are an example of type (2) knowledge. Tasks of type (1) cannot be formalized in terms of models, except in so far as they overlap with type (2), that is, when they are not mere acquaintances with a possibility, but actual knowledge of how to perform it. Type (3) tasks cannot be formalized either, because uncertainty cannot be teduced to logical relationships, however, as in type (1) some formalization is attempted in the areas overlapping with type (2).

An analytical framework is emerging: the formalization of training is likely to develop if the task(s) has few degrees of freedom. Division of labour and capital intensive technologies have developed in processes that have been split into subprocesses, which transform the problem of coping with many degrees of freedom, and hence a large number of possible trade-offs, into a set of problems with a limited number of degrees of freedom. Assembly lines are a good instance of such an approach to producing with a complex technology.

The failure to identify subprocesses and the underlying functional relationships precludes (physical) capital-intensive methods. An intuitive example is painting. Formal training in this area is relatively limited since very few relationships are known. Another interesting example is entrepreneurial activity -- the very activity of choosing amongst uncertain alternatives. For no matter how large it is, the amount of resources devoted to document and analyse the set of feasible options, in the end, a choice decides a future course of action with imperfect knowledge of past outcomes. This jump from information about the past into the unknown, and uncertain future, cannot be rigorously captured by logical relationships[1] and this is what prevents the development of a formalized training on decision under uncertainty; such a skill can only be practised or learned on-the-job-making decisions.

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[1] G.L.S.Shackle, Epistemics and Economics. A Critique of Economic Theories (Cambridge; Cambridge University Press, 1972) p.23.

Thus, a highly firm-specific training is also general training in so far as a generic type of problem solving is being exercised, and the specificity is confined to part, or all, data and variables used.

Therefore, it can be concluded that training defined as problem-solving, together with uncertainty and the degree of understanding of the logical relationships that underlie the tasks performed, are the basic components of (1) the explanation of how formal training develops; and (2) of the differences in the degree of formalization of training among different skills. The same approach is followed in the analysis of screening and signaling; an issue that must not be dodged since the content of formal training is economically relevant.

2.6 Problem-Solving, Screening and Signaling[1]

To state that formal training does not add substantive capacities is empirically unacceptable, for even in the less favourable case, formal training familiarizes the trainee with concepts, information, manual processes, etc., that resemble the tasks performed on-the-job: handling information useful in the solution of the problems encountered in the performance of productive tasks.

Formal training may or may not identify innate abilities, such as, say, attitudes toward risk, but it certainly provides trainees with information (acquaintance with ranges of problems, interactions, feasible solutions, etc.). Moreover, formal training can offer opportunities for problem-solving on a range of problems, generally defined by a set of variables, like, for instance, architecture and carpentry.

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[2] The concept of screening and signaling are used as in John K.Arrow, 'Higher Education as a Filter', Journal of Public Economics 2 (July,1973) and Michael Spence, 'Job Market Signaling', Quarterly Journal of Economics 87 (August 1973): Screening views formal training as a selection process, whereas signaling stresses the informational value of formal training regardless of what formal training actually does to trainees.

I have shown that formal training is likely to be developed for those jobs with tasks which are well-specified since trade-offs among the variables are functionally specified and thereby the typology of problems to be learned can be tailored according to what is currently done at the workplace. Examples are easy to find: carpentry, civil engineering, car driving, etc.

Where tasks are not well specified, or uncertainty is high, say, entrepreneurial activity, or research in new areas of physics, the content of formal training cannot be similar to the actual work activities; assignments in these fields are essentially irreproducible. Manpower that performs these tasks can expect from formal training no more than descriptive information, practice in how to generate (find) relevant information, and practice in the general ability to state, and solve, problems irrespective of the type of variables handled. I must also add that this tends to be the case with new skills.

A conclusion to be drawn is that the degree of specificity of a given skill limits the development of training syllabi specific to these skills. However, training based on generic problem-solving and in getting familiar with descriptive information does not imply that formal training merely identifies innate attributes.

That education does not widen the productive abilities of individuals is a proposition that defies empirical evidence. Can anyone question that learning arithmetic, reading, and writing do not train for production? Is it not a problem-solving activity to learn them?

Whether or not they are cost-effective, for certain on all jobs, is a different problem; and so it is the proficiency in the command of such knowledge. A related issue is the relative efficiency of formal training as compared with training on the job.

Disaggregated studies comparing formal training and jobs is what is needed to estimate the relative worth of alternative training processes, and the signaling value of certificates and syllabi. It is unlikely that tests of screening using aggregate data classified by educational level, and unrelated to occupation analysis, will ever produce any fruitful evidence. Schools and workplaces have to be investigated, together with research of what constitutes innate abilities, acquired abilities, and how they interact. For, are risk-attitudes innate, acquired or a combination of both? Or is problem-solving an innate or acquired skill, or a mix of both? Answers to these questions would surely improve the understanding of the economic value of formal training, and of the accumulation of knowledge by individuals throughout their lives.

In other words, the degree of similarity between the contents of jobs and formal training determines the signaling value of training syllabi and of training certificates in particular. Where the resemblance is less apparent the signalling value of training diminishes; but, this is, after all, a reflection of the prevailing uncertainty and poor information of certain tasks, and of new skills in particular.

New technology is usually poorly understood. The functional relationships are not clear and choices, in this context, have to allow for a margin of error between expected and realized outcomes. In short, formal training when defined as problem-solving is not compatible with the screening hypothesis, but it makes possible the identification of the signaling value of formal training. Problem-solving is relevant in this context as well as in the choices of training investments made by employees. Having given content to the concept of training, and after the analysis of formal training the issues to be discussed next are the demand for, and supply of, training: the why and how economic units invest in training.

2.7 Problem Solving, Sequential Choices and Mobility

Job and training choices by employees are not different from employers' hiring and training practices, in so far as they have to ascertain the relative attractiveness of the options available. Job seekers, specially those who enter the labour force for the first time, are not likely to know much about employments because knowledge is costly. Besides, many jobs are poorly specified and it is difficult to estimate their content, and what are the most cost-efficient skills. This is particularly so for new skills, since employers do not know much about them, and job incumbents offer conflicting assessments.

Under uncertainty and imperfect information, the efficient approach to discovering which job offers the largest net total advantage is to follow a sequence of choices, to be flexible, conjecturing the lowest cost of adapting to change and to better information; as the latter is likely to be accumulated in the course of the working activity, at a rate influenced by the amount invested in searching.

Non-pecuniary considerations affect job choices and mobility. Individuals do not compare only earnings differentials but the whole of net differences. Moreover, they only learn gradually about different jobs and about what they prefer because information is imperfect and

and costly; and in addition, job offers and tastes, vary with time.

To the extent that job and training offers differ across firms and over time, mobility is likely to be a feature of labour markets, since employees enter the market with ignorance or low knowledge of the difference among the openings available. New technologies are bound to be specially affected by labour mobility owing to employees ignorance being compounded by the inherent difficulty in finding out what skills are demanded. The unreliability of market indicators is partly due to the low homogeneity of process and input specifications that are used. Employees in these circumstances soon realise the importance of technical and economic change, the limitations of their foresight, and the cost-effectiveness of undertaking a sequence of job and training choices.

A major under-researched problem is the relative attractiveness of jobs that differ in the degree of uncertainty. How far do attitudes to uncertainty influence job and training choices ought to be discussed, for the empirical evidence of this research indicates that this variable plays an important role.

2.8 Internal Markets and Training Mixes in New Skills

Doeringer and Piore define the concept of <u>internal labour market</u> as

> "an administrative unit, such as a manufacturing plant within which the pricing and allocation of labour is governed by a set of administrative rules and procedures."[1]

My exposition is in terms of "internal markets" for labour and capital since both, labour and capital, interact in the decision-making involved in resource allocation. <u>Firms are always "internal markets"</u>

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[1] Peter B.Doeringer and Michael J.Piore, <u>Internal Labour Markets and Manpower Analysis</u> (Lexington, Mass: D.C.Heath and Company 1971), pp.1-2.

The employer decides on resource allocation, on the combination of labour and capital, after having considered labour demands and the possibilities offered by physical capital already in the firm. Thus, I extend the concept of internal labour market to the allocation of capital inputs because the firms cannot allocate labour following a set of internal rules and capital according to the market. Labour and capital are technologically interrelated and administrative constraints upon either of them amounts to limiting the choices concerning the other input. Moreover, information on labour and capital is neither perfect nor costless, although it may often be cost-effective to invest in information on internal resources rather than on external ones. This will depend on the characteristics of the firm, which means institutional arrangements, input and output specifications, degree of uncertainty, employees control of the process of resource allocation etc.

"Internal markets" are efficient in generating information about heterogeneous resources, and consequently, they can reduce transaction costs (lower mobility) and the degree of uncertainty.[1] An example is provided by training on-the-job, for the monitoring of trainees progress can produce a signal of the employee's potential ability to learn and to adapt to change. The monitoring of trainees advance is often found in commercial computing in Spain. During this research, evidence on this practice was also found in other areas, for instance, in several banks and manufacturing firms.

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[1] As Armen A.Alchian and Harold Demsetz remark: "Efficient production with heterogeneous resources is a result not of having better resources but in knowing more accurately the relative productive performance of those resources", 'Production, Information Costs, and Economic Organization', American Economic Review 62 (December 1972): 793.

New technologies are likely to lead to the development of "internal markets", as information is normally imperfect, and uncertainty very important. Besides, resources and output demands are seldom homogeneous or standardized; production processes tend to be highly specific and, consequently a large proportion of training is specific.

The technological specificity of training, in new technologies is, however, not necessarily equivalent to economic specificity, for in a different sense, such training is essentially general. While many concrete aspects learned are specific to the training firm and cannot be transferred to another firm due to differences in process design, there is a feature that makes it suitable for other firms: highly-specific, non-formalized, training consists basically in problem-solving under imperfect information and uncertainty; and this is precisely the skill demanded by firms involved in new technology. The features of the problems to be solved are not the difficult part, but getting a working design.

"Internal markets" differ from one another, and so does training on-the-job. The background of the candidates together with the institutional characteristics of the firm will condition the skill content of jobs, training options, and the training mixes chosen by people. Inter-firm heterogeneity stimulates mobility among those who are not satisfied with job content, training prospects, or any other facet of the employment currently held. Employees learn what training opportunities are open in the current employment and elsewhere. In one firm, perhaps, a broad and shallow range of training options may be offered, in another only a limited set of in-depth training offers are available.[1]

Thus, the argument is not about employment and training choices in response to price differentials which is what Becker's approach amounts to. Nor is it about a market providing a variety of work-learning opportunities, that is, a market for learning opportunities.[2] My analysis points towards a "job-competition" model[3] with high uncertainty and information costs: jobs offer wages, training, and non-pecuniary advantages and disadvantages.

Training choices depend on multiple factors; earnings differentials and direct training costs are merely two of the multiple considerations likely to influence training choices. This is particularly so among new skills where uncertainty is important; and there exists a wide variety of profiles among job incumbents. Career patterns diverge considerably for the same reasons. Risk attitudes, the psychological attractiveness of tasks and of the work environment, are not easily evaluated in this context. "Internal markets" help to reduce uncertainty, but they also constrain choices and lead to differences among firms and among the training mix and career pattern chosen by employees. Such a situation will gradually change in favour of a greater role of the external market as technical change and relative costslead to standardization of processes, inputs, and outputs.

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1 This distinction between breadth and depth of training options is based on Scoville, op.cit., chapter 3.

2 Sherwin Rosen, "Learning and Experience in the Labour Market", Journal of Human Resources 7 (Summer 1972): 326-342

3 Thurow, op. cit. p.389.

The choice of a training mix is also influenced by the way individuals appraise obsolescence, an important factor in new skills. When a new technology comes to the market, the design is somewhat provisional; before it consolidates many modifications are introduced on the initial design. Thus, learning a new technique in its first (marketed) stage is not necessarily efficient. New technology is learned solving the problems that emerge when trying to make it operational, and there is no obvious reason for problem solving with the newest design to be more cost-effective than with a refined version. The market value of the ability to solve certain problems is bound to depend on the "extent of the market" -- an issue to be elaborated further in Chapter 3.

In short, training in new technologies leads to a variety of skill mixes that together with the heterogeneity of job incumbents and the high elasticity of substitution reduces the analytical value of occupational classifications. In consequence, a representative profile of a job incumbent cannot be produced. However, something is learned by analysing the econcmic and technical characteristics of job design.

2.9 Job Design, Occupational Groups and Elasticity of Substitution

The design of jobs, their specificity, will partly depend on the level of uncertainty and on the number of degrees of freedom of the technology. Caeteris paribus, the larger the number of degrees of freedom, or the higher the level of uncertainty, the less specific a job will be, and thereby the higher the elasticity of substitution among jobs with these characteristics, regardless of their belonging to sectors using different technologies. The intersectoral mobility of manager-entrepreneurs is a case in point. The speciality in economic terms does not have to be defined by the economic sector they work in, but by the characteristics of their activity (decision-making under uncertainty) because an input is a set of perfect substitutes.

Low formalization of tasks results in a non-existence of formalized training, as well as of widely accepted standards of selection. Though it is sometimes implied that standards of selection and profiles of an occupation can be obtained from job analysis, this is not necessarily so. Mark Blaug, et al, state:

> "...occupations must be defined in terms of the nature of the job, without any reference to the characteristics of the people who will or should take them up"[1]

in an effort to circumvent the limitations of occupational classifications based on the educational profiles of job incumbents, due to their being the result of demand and supply considerations. "Job-analysis", together with "job-specification" and "job-evaluation", suffer from the same weakness: the design of jobs is not an invariant, but a decision variable that is influenced by supply and demand, particularly in new technologies. Chapter 3 provides an illustration with commercial computing.

First of all, there is no such thing as a technologically given relationship between a job and manpower, both are determined under the influence of technological and economic considerations: <u>the actual design of a job and the level of training are decision variables, and so is the technology (physical capital) that conditions the types of jobs that can be designed</u>.

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1 Mark Blaug, Maruice H.Peston and Adrian Ziderman, <u>The Utilization of Educated Manpower in Industry. A Preliminary Report</u> (Edinburgh: Oliver and Boyd, 1967), p.43.

In addition the concept of occupation is not very useful in new tasks, because the poor specification of the man-machine interface in new technologies, and the large degree of uncertainty, lead to a high elasticity of substitution -- empirically reflected in the wide variety of profiles of job incumbents.

New technologies are bound to employ people with a variety of backgrounds, in so far as they leave to men those tasks with uncertainty and larger number of degrees of freedom; for the attributes that are demanded from manpower are the capacity to deal with uncertainty and the ability to build ad-hoc models -- that is what problem-solving on-the-job consists of, when formal training has not preceded the performance of a task.

Similarly with the relationship between occupations, job design, and skill "requirements". Loose technical specifications cannot be expected to produce well-defined jobs, nor occupational categories since, individuals with very different backgrounds can qualify for the different sets of tasks that can result from the multiplicity of job designs that are feasible and likely to be generated as relative costs change over time. "Job-analysis" like "the manpower requirements approach" assume fixed coefficients, the former between technology or the design of a job and skills, the latter between occupations and education. The assumption becomes untenable as soon as it is realized that job designing is a decision variable. Moreover, job design and recruitment policies are likely to be influenced by the background and group strategy of job incumbents.

In brief, the analysis of the design, the concept of occupation, the difficulties in determining the relative efficiency of different profiles of job incumbents, and the ambiguities of the technique chosen due to uncertainty and being imperfectly understood, and their being viewed by decision makers as variables leads to the dismissal of the concept of micro-production function in the analysis of training. The clarification of these issues makes for a more efficient discussion of manpower shortages.

2.10 Decision-Making, Interdependent Marginal Productivity and Manpower Shortages

I discuss in this section the analytical and empirical difficulties that surround the investigation of labour shortages, as the leading problem of this research is the alleged manpower shortage in commercial computing in Spain.

Economists do not coincide in the definition of a manpower shortage. Blank and Stigler[1] define the "salary rise shortage" as a rise in the salary of an occupation which is relatively larger than the rise in other occupations, since demand at current prices is larger than supply. The "dynamic shortage" of Arrow and Capron[2] is defined in terms of vacancies that are not filled because the wage is too low to clear the market. Moreover, intervention in the labour market can also prevent wages from rising when demand is larger than supply at the current wage, that is Folk's "controlled price shortage".[3]

[1] David M.Blank Washington and George J.Stigler, The Demand and Supply of Scientific Personnel (Washington: National Bureau of Economic Research, 1954), p.24.

[2] John K.Arrow and William M.Capron, "Dynamic Shortages and Price Rises: the Engineering-Scientist Case, Quarterly Journal of Economics 73 (December 195

[3] Hugh Folk, The Shortage of Scientists and Engineers (Lexington, Mass: D.C.Heath and Company, 1970), p.3.

Differences aside, these concepts show two common features: (1) manpower shortages of an occupation appear when the demand increases more than the supply, (2) wages are a central variable in the determination of the size of the shortage.

Presumably, the underlying interest in manpower shortages is based on the belief that price rises and lagged adjustments are inefficient.[1] However, there is no a priori reason for such a belief. First of all there is no theoretical reason in favour of stable relative prices. Furthermore, for a changing economy the contrary is true, since relative scarcities change over time. How large a price differential must be, for a change of supply to take place, is an empirical question; even a price inelastic supply is not necessarily inefficient.[2] Neither economic theory nor technology can tell what the output mix, or the structure of relative prices, should be; they are determined by the choices of economic agents. As for lags in the process of adjustment the answer is also likely to be ambiguous. A comparison of prices and quantities demanded and supplied can never provide all the relevant information. Adjustments lags partly depend on the design of production processes, say, the structure and duration of college degrees. That a redesign of these processes is bound to alter the lags in markets that recruit college graduates, seems predictable. However, from this it cannot be inferred that current lags are inefficient.

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1 "The utilization problem was recognized as a result of the rising salaries and vacancies of the 1950's ...The apparent contradictions of a labour market in which employers bid vigorously against each other with government money for engineers, while government agencies and universities were unable to compete in salary, were too obvious to be brushed off as part of 'the normal working of a competitive labour market'." Ibid. p.15.

2 "The <u>salary-rise shortage</u> was not a problem; rather it was a necessary result of the adjustment process. The <u>dynamic shortage</u> reflected the adjustment process, especiallythe <u>controlled-price shortage</u> for schools, universities and government. The projected <u>supply shortfall</u> the arithmetic difference between projected requirements and projected supply never occurred, because firms adjusted the manpower limitations by substituting other factors for engineers and scientists, and because R. & D. plans were cut back." Ibid., p.17

So far I have shown: (1) the role played by choices of technique and job redesign; (2) how production processes are neither fully understood, and specified, nor are they invariants; (3) adjustments at the micro-economic level are not confined to prices and quantities; and (4) most resources are heterogeneous. Moreover, prices even when they can be measured their meaning is ambiguous, since they are one, among several dimensions (degrees of freedom) that can be manipulated by decision-makers. Despite what is often stated, prices cannot tell whether a market is efficient, for price equality is a valid indicator only when all other dimensions of a resource. Adam Smith's advantages and disadvantages--are equalized; a situation that is not frequently found in labour markets, particularly in those of advanced technologies.

Taking prices as a proxy for the total net advantages may be useful, and casual observation shows that firms often do so. Whether this is always valid is an empirical question, and, of course, a matter of cost-effectiveness. This approach cannot be accepted in labour markets for new technologies since heterogeneity, and hence the degrees of freedom, are so high that the information value of (aggregated) prices is ambiguous. Thus, even in the best of cases the measurement of (macro-economic) manpower shortages is difficult and of dubious value for policy purposes. The empirical determination of an occupation is always an arbitrary decision,[1] and the actual specification of an occupation will affect the interpretation of the measured shortage through the impact on the scope for substitution.

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1 This is clearly shown by Folk, op.cit. Chapter 3. P.R.G.Layard, J.D.Sargan, M.E.Ager and D.J.Jones, Qualified Manpower and Economic Performance. An Inter-Plant Study in the Electrical Engineering Industry (London: Allen Lane. The Penguin Press) pp. 101 and 105; J.D.Mace and S.M.Taylor, "The Demand for Engineers in British Industry; Some Implications for Manpower Forecasting", British Journal of Industrial Relations, 13 (1975): 180

Sensitivity analysis can circumvent this weakness only to a point, since the analysis of the cost-effectiveness of alternative policies geared to modify the shortage, or to let things as they are, will also depend on the scope for substitution. The dilemma is of difficult solution since, caeteris paribus, variable-coefficient processes tend to respond with shorter lags and produce a lower volume of output than fixed coefficients production functions. The estimation of the relative worth of flexibility is beyond current economics since the conjectured value would depend on the uncertain future.

As an illustration it can be stated that, ex ante, a design of a production process that produces X_1 units of a given product and takes T_1 units of time to increase output by x, is neither more, nor equal or less, efficient than a design of the same production process that produces X_2 units of the same product and takes T_2 units of time to increase output by x units, ($X_1 > X_2$ and $T_1 > T_2$). The two processes are different. In wealth terms, suppliers and demanders are not indifferent to the production design chosen; the difficulty, however, is that the technology is chosen under uncertainty and whichever way the choice goes, an opportunity cost is faced: either a lower level of output or a larger adjustment lag.

Thus, a manpower shortage cannot be reliably estimated or forecast. This follows from the way occupations are specified, but, more fundamentally, because of the ambiguous meaning of manpower shortages. These considerations are even more important for manpower in new technologies since heterogeneity (degrees of freedom) is high, and uncertainty puts a premium on flexibility; thus making price adjustment relatively less important and occupational classifications less meaningful.

Conclusion

This chapter has developed a discussion of training in new technologies leading to four main specifications:

(1) training consists of problem solving

(2) staffing and training decisions are components of choice of technique

(3) the degree of uncertainty, and the number of degrees of freedom, of a set of problems are analytically relevant for training and the types of training available - on the job and off the job (formal training)

(4) the efficient production dichotomy is not between movements along, and shifts of, the production function but between flexibility to face uncertainty and standardization to maximise physical output for a well-defined set of constraints. The concept of micro-production function is logically inconsistent with choice of technique and training under uncertainty.

(5) New skills have many degrees of freedom and are highly influenced by uncertainty. Wages are but one policy variable. Thereby wages or any other dimension alone cannot provide an unambiguous measure of training issues; several not just one parameter are needed in empirical studies of training. A "job-competition" model under uncertainty is more appropriate than a "wage-competition" model of training.

With this analytical apparatus the emergence of formal training, screening, signaling, job design, occupational and training choices and manpower shortages have been analysed. In the analysis of the training market in commercial computing in Chapter 3, I show that training choices and the demand for specialists cannot be discussed without first studying what determines the adoption of technology, that is, the choices of technique.

Chapter 3

TRAINING IN COMMERCIAL COMPUTING

3.1 Introduction

This chapter analyses training in commercial computing using the theoretical framework developed in Chapter 2. The sources are both bibliographical and empirical. The latter evidence is from Spanish commercial computing and it was obtained in the interviews referred to in Chapter 1.[1]

I concentrate the analysis on those skills that are considered most sophisticated, such as systems analysis and software programming. Computer programming is analysed in greater detail because it provides a good example of the historical evolution of a set of new skills with a high problem-solving content that has gradually become standardized. I do not study tasks such as key-punching, as they are fairly routine-type tasks, the training scope seems much more reduced than that of the skills to be analyzed in this research and, it appeared to me, a priori, that the latter group present problems more akin to those studied by researchers on conventional manual skills.

Training issues are raised after a summarized description of computer technology. Such an introduction is instrumental in showing the characteristics, and flexibility, of the processes that constitute commercial computing, as they reveal the scope for training choices and,

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[1] Formal training and manpower shortages in commercial computing are dealt with in Chapter 4, because of the singularities of the Spanish evidence in these areas. As for the other issues, what has been observed in Spain coincides with evidence from the UK and other countries. The main sources of information have been: A.B.Frielink, ed., International Symposium on Economics of Informatics. Proceedings, (Rome: Intergovernmental Bureau for Informatics/IBI-ICC, 1974); Communications of the ACM (monthly), Datamation, Financial Times.

more fundamentally, the influence of choice of technique on the supply and demand for training.

3.2 Electronic Computers

An electronic computer or, more accurately, a computer system is a collection of interacting devices that can process (classify, compute, etc.,) at great speed any kind of information, provided that such information is fed into it in mathematical form. The ability to iterate repeatedly the same short description of a basic mathematical process is what makes it so powerful.[1] It is universal because the information to be processed does not have to be of numerical nature and only what cannot be done following a mathematical model, has to be performed by human skill, with or without the aid of conventional machines.[2]

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1 What distinguishes a computer from conventional calculating machines is the logic of the design materialized in an arithmetic unit, a memory, a control and input-output device. Electronic devices are only instrumental insofar as their capabilities make possible designs that were either unattainable with other technologies, electromechanical or magnetic, or that were not cost-effective. Neither the supporting technology nor the logic designs are fully understood; many alternative developments coexist in both areas. A very concise exposition of these alternative approaches is found in John von Neumann, The Computer and the Brain (New Haven: Yale University Press, 1958). An account of the early stages of this evolution and the prevailing uncertainty as to the outcomes of the research efforts is offered by Herman H. Goldstine, The Computer from Pascal to Von Neumann (Princeton: Princeton University Press, 1972). A survey on current research and problems in computing and related fields can be found in Communications of the ACM 15, (July 1972).

2 Conventional devices, such as Hollerith's tabulator, were also logical designs that solved (fully specified) problems. The main differences with the (von Neumann) computer are the control and memory units which give greater flexibility and generality to their processing capabilities.

Speed of computation was demanded in the 1940's in order to perform complex and lengthy calculations.[1] Electronic technology was seen as potentially more promising than electromechanical devices since the latter are less suited for processes that require great speeds.

The speed at which the information is processed, once in the computer, is not the only decisive variable in commercial computing. Account must be taken also of the nature of the information processed--it is bulky and easy to compute--and more generally, of the objectives that have to be attained by computerized information systems. And to the flexibility and multi-dimensional character of commercial computing I devote the next section.

3.3 Uncertainty, Degrees of Freedom and Variable Proportions

A computerized data processing system can be considered as a collection of resources (processing units, transducers, storages, systems programmes and manpower) that tend to be highly nonlinear and interactive. Users make multiple, and often poorly specified or incompatible, demands for these resources. A user's demand can be processed using a variety of combinations of dated resources. Moreover, due to nonlinearities and interactions, the production function for information processing is not simply a relationship between dated inputs, manpower, processing units, etc. and output. It also includes the job stream and the objectives of the system (reliability, response time, etc.).

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1 Scientific and engineering computation basically requires fast processing because the calculations demanded are either very lengthy or the results are used to control operations in "real time" - automatic "feed-back" systems. It is because of this precise performance requirement that early designs were developed to meet the speed specification.

The system configuration, or system resources (all devices and software parameters) is not a datum it can be modified at a cost. Besides, its performance depends on the characteristics of the job stream (length, complexity, frequency, etc.) and the constraining effect of the targets of the system (level of reliability, response time, etc.). In short, data processing has a "variable-coefficient production function."[1] The computer specialist is faced with a

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1 There are:

"twelve dimensions for measuring the effectiveness of a computer system, individual scales of measurement have yet to be established ... in current practice, a designer uses his experience and judgement to apply qualitatively the systems objectives".

The systems objectives are:

"1. EFFICIENCY	- computer resources, being expensive, should be used wisely (e.g.: reduce sorting, seeking and sizes of files and programmes)
2. TIMELINESS	- Response/turnaround times must be met under normal, peak and recovery conditions.
3. SECURITY	- Hardware/software breakdowns must be recoverable.
4. ACCURACY	- The (input/output) system must work to an acceptable level.
5. COMPATIBILITY	- The system must fit the total, integrated system.
6. IMPLEMENTABILITY	- The system must be built from available resources.
7. MAINTAINABILITY	- Subsequently, the system must be modified from continuing resources (e.g.: maintenance programmers may not be as skilled as implementation programmers).
8. FLEXIBILITY	- Systems algebra is dynamic.
9. ROBUSTNESS	- Systems arithmetic is dynamic.
10. PORTABILITY	- Systems hardware/software is dynamic.
11. ACCEPTABILITY	- Design standards should be observed.
12. ECONOMY	- The system should be cost-effective or cost beneficial when compared against its alternatives."

Sam J.Waters, 'Efficient Computer Systems Design', International Symposium of Economics of Informatics, pp. 210 and 217.

resource allocation problem that must be programmed - a mathematical solution for the workload or job stream to be processed.

The problem is one of choice of technique: of combining imperfectly understood tools and the ways they interact, to meet an incompletely specified demand that changes over time. In other words, the computer specialist has to produce a solution, knowing that there are many trade-offs, and some of them are specific to the devices used, others are difficult to measure, or even to understand.[1] The individual realizes that there are no single, unambiguous specifications, and that choices have to be made and consequently problem solving, that is, training varies from installation to installation.

Commercial applications (payroll, stock control, etc.) have traditionally been developed by trial and error. Ad hoc changes are usually introduced over time. Acquisition of information is the answer to imperfect knowledge. The heuristic approach in the choice of technique and the design of computerized processes is the consequence of ignorance as to the generating of information and the poor specifi-

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1 "The very wide class of problems executable by a computer system, the mixed-speed resource structure of systems, and the differences in resource use by different jobs require that any performance measures include a specification of the workload. This is a most delicate process. One reason is that we have no theory of performance evaluation that permits us to deduce system performance on one workload from known performance on another ... there is really no such thing as a simple "general" evaluation of a structure as complex as a computer system; each performance study must first decide on its goals and then specifically reflect these in the choice of workload and performance measures."
Herbert Hellerman and Thomas F.Conroy, Computer System Performance (New York: McGraw-Hill Book Company, 1975), p.12. The conclusion to be drawn is not that users cannot obtain performance estimates but, rather that the participant resources can be combined in different ways, that their actual performance depends on the design of the systems and on the job(s) processed, and finally, that their performance can only be roughly approximated.

fication of the information demanded.[1] The latter partly derives from the imperfect understanding of current phenomena and from the limited capacity to take into consideration change and uncertainty that is generated. It also exemplifies the choice of flexible and loosely specified arrangements -- for both physical, and human, capital, and therefore for training -- in an effort to adopt defensive measures against those major and continuous decisions which offer a considerable degree of uncertainty.

Fast computation can be cost effective but it requires logically thought out designs (mathematical models) of the information to be processed -- this amounts to saying that machines are substitutes for labour (mostly clerical) and complementary with highly skilled labour (model builders). In general terms, mechanization only replaces labour performing well specified tasks; for the new tasks that emerge, as they are not usually fully understood, human skills are devoted to perform them. This is not, of course, the same as saying that all well defined tasks are mechanized. This stronger statement is not likely to be true for the simple reason that automation, or even partial mechanization, is introduced only if it is more efficient than current methods.

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1 "Due to the broad, diffuse, and ill-defined spectrum of user requirements, most existing manufacturer-offered operating systems are built on the concept of functional, that is horizontal, modularity. [IBM] OS/360 is a good example of this construction. [IBM] OS/360 was originally, and to a large extent still is, designed as a kit of tools, techniques and functions from which one may select, assemble and construct a system to meet a hopefully well-defined requirement of the end user. In such a system we have many ways of doing the same thing and many different pieces of hardware for accomplishing the same function. The end user is to select a set of hardware and software modules and assemble them together to provide an optimized system to meet his requirements."
W.C.Lynch, 'Operating System Performance', Communications of the ACM. 15, (July 1972): 582.

New tasks and training arise in information production from changes in technology which are due to: (1) the piecemeal approach to technical improvements; (2) to innovations in other sectors; and (3) to the feed-back from users of improved equipment. In other words, advances in the mechanization of information processing have often taken place when research improvement has been directed at solving specific performance specifications. In addition, improvements in one requirement have frequently resulted in new demands for information which, in turn, have influenced the direction of the research effort. This is so, partly because computerized processing combines equipment based on essentially different technologies. Electromechanical and magnetic technologies were, and still remain, important in this field though their relative importance has fluctuated over time.[1] Besides, these technologies have different degrees of engineering understanding, electronics being the less well known and mechanics the one whose capabilities and actual performance in industrial devices are best understood. Finally, these technologies are used in other sectors of the economy and, in consequence, technical change in computing has often originated elsewhere in the economy. This explains why the evolution of commercial computing has been continuous, but unpredictable in its rate and in its

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1 An historical account of the interactions and uncertainty between different technologies, innovations and trends in relative cost and demand is provided by Maurice V.Wilkes, 'Historical perspectives - Computer Architecture', Fall Joint Computer Conference 1972, Proceedings. Washington D.C. Spartan Books, 1972. In the same volume: J.H.Pomerene 'Historical Perspectives on Computers - Components', 977-983, Albert S.Hoagland, 'Mass Storage - Past, Present and Future', 985-991, Walter F.Bauer and Arthur M.Rosenberg 'Software - Historical Perspectives and Current Trends', 993-1107.

directions.[1]

Variable proportions and uncertainty of technical change affect choices of technique and the problems to be solved. These interactions have a bearing on opportunity costs and trade-offs in ways that deserve separate discussion.

3.4 Flexibility, Invariants and Problem-Solving

The computer specialist has to produce a cost-effective model for the processing of demands for information, such as payroll, sales ledger, etc. In very general terms the assignment amounts to standardizing processes, or parts thereof — reducing them to invariants -- in order to take advantage of the high processing speed offered by computer systems. The cost reduction from a mechanized processing of a previously normalized information must be set against two factors: firms do not live in a world of perfect certainty and information demands tend to change. In such an environment built-in flexibility in the process of generation of information is also economically efficient since it is likely to lower redesign costs.[2]

The job content of the computer specialist can be broken down into several tasks. The classification I have chosen is neither the only possible, nor imposed by technology. Nonetheless, it will be shown that it is economically meaningful, because it highlights the existence of

1 Semi-conductors are a good example of how much developments in other fields influence the evolution of commercial computing. The papers cited in footnote 1 on page 49 put semiconductors in perspective within commercial computing: they were in the market before electronic computing and their evolution cannot be explained by what has happened in commercial computing alone. The origins are well-documented in W.R.MacLaurin, Invention and Innovation in the Radio Industry (New York: The Macmillan Company, 1949) The more recent past is dealt with in John E.Tilton, International Diffusion of Technology (Washington, D.C.: The Brookings Institution, 1971).

2 Hart, op.cit. p.55

subprocesses with different opportunity costs when standardization is considered.[1]

Commercial computing can be divided into three groups on the basis of the types of variables --technical knowledge — that define the tasks performed. One group, systems analysis, encompasses the model building activity: matching the demands from the users of the information with the constraining implications of an unambiguous and logically consistent design. Another group, programming, contains the problems arising from the translation of the model into a stepwise process that the computer system will perform; the translation must be done making a cost effective use of the resources of the computer system. Finally, operations refer to the problems that emerge from the actual processing of the information by the computer. Obviously, the three sets can be enhanced by a single individual, as they are sequential and essentially all refer to logical processes. The sequence is, in practice, further broken down into several subsystems, each one composed of one or more tasks, leading to a more efficient use of each specialist's know-how, that is, an efficient use of the

1 Another classification gaining many adherents inserts between systems analysis and programming, another set of skills often called systems design consisting of task specifications of the subprocesses that constitute the borderline, broadly defined, between systems analysis and programming, as defined in this chapter:

"The computer systems design problem that is considered in this book can now be formally stated as follows:

GIVEN a definition of information processing requirements and a definition of resources,
DESIGN a computer system of files and programmes,
SATISFYING the required objectives of the system."

Sam J. Water,s Introduction to Computer Systems Design. Planning Files & Programmes (Manchester: NCC Publications, 1974) pp.22.

specialist's ability to solve a set of problems in which a given group of variables is predominant.

Thus the computer specialist, first of all, has to analyze the demands for information in relation to the resources available. Logically consistent objectives and specifications will be defined. Once it is known, the data dictionary, input and output messages, the data base and the processes involved, a second set of tasks leads to a detailed computer systems specification: processes are partitioned, files and programmes designed, and interfaces established. A third set of tasks corresponds to the programming of the systems specifications, that is, translating all the computational and logical, or decision, rules into a language understood by the computer system.

The next step will be the implementation of the designed process. A trial and error method is followed until a cost-effective solution is produced. It must be kept in mind that the process of designing a mechanized information system is based on a trial and error approach, since nothing is perfectly understood, and many trade-offs are feasible at any point in the process. Moreover, feed-backs are important in designing efficiently, since a systems specification can only gradually be made more and more cost-effective. In other words, the process of designing an information system consists of a gradual reduction of degrees of freedom --loss of flexibility -- of the information processed, and a consequent definition of temporary fixed coefficient subprocesses.

Apart from substitutions due to changes in the relative prices of the resources used, maintenance tasks take place due to failures in the system that cannot be predicted in advance. Other sources of post-implementation problem-solving are: changes in the specification of the information demanded by users, and the processing of new information, for they alter the performance of the system due to the interactions and nonlinearities that cannot be taken into account when information systems are designed as they are not fully understood by the computer specialist.

The tasks performed by the computer specialist have been classified following a sequence of decisions that progressively diminish the amount of flexibility of the information system. Maintenance tasks are, however, a combination of the tasks already cited and in fact, the process cannot be efficiently designed unless each step interacts with the previous ones, and changes in the intervening segments are brought about whenever it is discovered that a more cost-effective combination is feasible.

Two major considerations emerge: (a) the division of the resource-allocation problem involved in designing a computerized information system into a set of tasks can be illustrative but it is technically arbitrary, since the outcome of each task depends on all others: in mathematical language, a system of equations must be solved simultaneously, if the solution is to be optimal for the given set of constraints ; (b) the existence of trade-offs and the imperfect understanding of the technical characteristics, and possibilities, as well as the fact that the demand is usually inadequately specified precludes the option of defining a set of simultaneous equations and an heuristic approach must be followed. The resource allocation problem is divided into several subproblems that are solved separately, and only to some extent sequentially.

The partition of the problem into sub-units tends to be economically efficient because the number of degrees of freedom of each sub-problem is smaller. As these sub-systems are solved the system becomes more and more constrained and eventually a provisional solution is found. The specification achieved is likely to be inefficient and usually it pays to revise some parameters, following a basically "ad hoc" iterative process, until a cost-effective design is reached.

To the extent that there is no theory of information processing, the division of the resource allocation problem must be based on whatever knowledge has been accumulated by the specialist. Hence, if specialists have different know-how, work with different constraints (resources and demands), or both, training opportunities are likely to differ and there is no reason to infer that all specialists will be on the same "production function". In fact, it is unlikely that they will be on the same production function since this assumes, amongst other things, that all specialists are endowed with the same know-how: an empirical question that is first approached by studying the impact of the flexibility upon choice of technique, job design and training options.

3.5 Choice of Technique, Job Design and the Opportunities for Training

I start the exposition with an analysis of the evolution of programming skills and show how a loosely specified set of skills partly or fully performed by the so-called programmers, gradually evolved into several sets of skills, such as systems analysis, systems design, software programming and data-base management. A discussion of the design of hardware and software will follow, showing how technical change, and training opportunities, can neither be fully specified once and for all, nor do they depend on mere technical considerations. Market trends within and outisde commercial computing influence the direction and speed of changes.

The design of a computer with a stored programme in the 1940's resulted in the demand for a new skill -- giving mathematical formulation, and solution, to the processed data, numerical or otherwise. In other words, computer programming emerged and those who performed the task were called programmers. Initially, programming was machine orientated and machine specific, that is, the crucial thing was to make the computer process the application satisfactorily and the instructions were written in a code that was directly obeyed without any translation by the computer. It was a highly labour intensive task, very simple though not easy and certainly time consuming as it had to be expressed in great detail.

Programmers soon realised that certain segments of a programme were used repeatedly and hence it was convenient to have them as separate units (subroutines), thus avoiding reprogramming the same sequence of instructions. It was also noticed that programmes were difficult to test and modify, as they were long and ideosyncratic. All these considerations led to the gradual development of mathematical languages that simplified programming. This was achieved by combining mathematical languages, e.g. Fortran, Cobol, (mnemonic instruction codes) with an assembly programme that translated the mnemonic codes into numerical instruction codes. The former was easier to handle by the programmer, thanks to its similarity with everyday languages and it abridged programming by the use of fairly complex statements -- each one containing several instructions at the machine language level. The latter simplifying the programmer's task but reduced the degree of human control and, hence, his potential learning of the actual workings of the computer was also reduced.

Computerized information processing was introduced because it processed information at such speed that it was more efficient than the method superseded, even though its technology was not fully understood, it was obvious that there was room for improvement and therefore for problem solving. This explains why those new tasks which were to be performed in conjunction with the technical improvement provided "unavoidable" training options. The programmer, in the early days, could, but did not necessarily, learn a lot from work ("learning by doing") because the task to be performed (programming) was to be executed using a machine code language, a very generic tool.[1]

Whether or not the programmer did develop programming aids (subroutines) was left to his ingenuity and dedication. It involved a resource allocation decision: shifting his effort from current, ad hoc, programming to investing in the development and testing of

1 A tool can be simultaneously generic and specific from a technical point of view. This depends on the design of the interface with other devices. A machine code language is highly generic from the standpoint of the programmer and it is highly specific in relation to the computer. The opposite holds true for symbolic languages (Cobol, Fortran, etc.). Assembler languages are in an intermediate position. In general the first few designs of a new technical device are usually highly specific in their interface with other devices because their specifications tend to be strongly dependent on the particular technology that supports them.

subroutines that would simplify future programming.

The realization that programming could be standardized and made relatively simpler, gained adherents with the continuous increase in the speed of central processors. Substitution of higher level languages for machine code languages was efficient as programming in machine code was highly labour intensive and processing was becoming cheaper.

Higher level languages are less versatile -- they have more constraints -- and its statements are sets of predetermined instructions that are invariants to the programmer. Moreover, to the extent to which such languages are not machine specific, programmers have less scope for learning by doing for they learn to programme in Cobol, for instance, a language which can be fed into most computers, whereas with machine code languages one learned to programme a given machine, and programming another one meant learning aspects of programming that were machine specific and hence the change of machine implied some new learning.

Programming skills became more specific as the range of variables, and combinations thereof, was reduced by higher level languages. A process that coincided with a tendency to divide into systems analysis and programming the development of the model that would transform user's information into an input that could be fed into the computer. The former concentrates in the specification of a logically consistent model from information and output demands that are rarely systematic and consistent. The latter, programming narrowly defined,works on problems with fewer degrees of freedom and a lower degree of uncertainty.

The all-embracing tasks of early programmers was further reduced by the progressive complexity of computer installations. The central processor ceased to be the main constraint; a set of devices, peripherals, were being added to it and the poor understanding of the interactions among these devices led to the development of a new set of skills, software programming, dealing with the programming of the integrated functioning of all the devices -- the computer system.

In the early days designing programmes that could be processed was the main constraint. Those who "understood" the computer were the key specialists. Programming, mathematical model building, was a very relevant skill. As computer systems and symbolic programming languages simplified (standardized) the translation of the mathematical model of the information-input into a set of instructions that could be fed into the computer, the actual translation became less and less demanding in terms of problem solving. Nowadays programming is easier. It requires less training since the scope for problem solving is narrower.

Systems analysis, software programming and data-base management are now some of the most demanding skills in terms of problem solving as they have to deal with a large number of variables whose inter-relations are hardly formalized. Moreover, programming tasks, as they are currently performed, involve very little uncertainty, since they consist of solving well-defined problems under given unambiguous constraints. This is not the case of systems analysts and software programmers; their decisions have consequences that sometimes are not known until the process has been performed, or changes in the user's demands affect the relative cost-effectiveness of the solutions chosen.

This changing scene is likely to be better understood if computer manufacturing is dealt with. The design of computers leads to the accumulation of knowledge that is not unavoidable. Designers start off with a know-how which is applied to solve a problem, say, to compute complex calculations faster than conventional methods. The initial know-how cannot take designers beyond the definition of a plausible design and development and testing outline. Generally, the project is based on an imperfect understanding of the technology involved, and hence engineering specifications and reliability standards demand frequent choices as to what, and how, specific components, or processes, should be tested. Knowledge gained from each one of these research assignments is likely to increase over time, but a cost is incurred. The inputs used in one assignment could be used in advancing knowledge in other parts of the project.

Choices as to what devices should be improved are made under uncertainty, as it is not always obvious which development is likely to be more productive. Moreover, other industries also offer more cost-effective technologies. Transistors are a good example. The substitution of transistors for vacuum tubes did not take place when technology was "fully mastered" but when it was realised that its average performance and reliability was superior to vacuum tube technology. It pays to use a "half-baked" technology whenever it is more efficient than the one currently in use. Furthermore, it pays to invest in improving the engineering design only when it is estimated that the resulting increase in efficiency from the improvement will outweigh the cost involved in discovering (learning) it. This process will continue until it is realised that further investment in improvements are not profitable.

The conclusions to be drawn from the analysis of the evolution of programming are that (1) job designs, skills demanded and occupational label are not invariants in commercial computing -- they depend on the choice of technique under uncertainty. A job specification in 1965, say, a programming job, is essentially different from a programming job as defined in 1975 apart from any consideration of interfirm differences, (2) problem solving, degrees of freedom and uncertainty are analytically efficient in the explanation of the evolution of training in commercial computing, and (3) the flexibility and evolution of job design partly depend on the interaction among demand and supply in commercial computing and the evolution of industries that use technologies relevant in commercial computing.

Having shown the fundamental influence of choice of technique on the scope for training in commercial computing and the evolution of skills and job design over time, a specific reference to the computer specialist market is made, since training options depend on access to jobs.

3.6 Division of Labour, Access to Jobs and Demand for Training

Assuming that computer specialists maximize pecuniary, and nonpecuniary, returns from their working activities, it can be stated that, caeteris paribus, a computer specialist will take an employment that offers the widest scope for skill-acquisition, or training for short. This follows from the differential that will be offered by employers who demand such skill.

It is also assumed that: (1) workers are free to choose employment; and (2) workers know that employers differ in the amount of training they offer. The first assumption does not require further elaboration. The second can be substantiated by just saying that a computerized processing of information varies, at least, from industry to industry since the variables and parameters differ significantly. For instance, a commercial airline has an application, the ticket reservation system, with variables and parameters that are not encountered in, say, the information system of a chocolate manufacturer, and that is why one type of training can only be applied to another environment at a cost.

Moving into the supply side of training, it can be stated that the division of labour in commercial computing owes its existence to efficiencies resulting from complementarities between different types of labour and physical capital, and to the substitution of expensive inputs (labour specialized in solving problems) by cheaper inputs (physical capital and labour with relatively low problem-solving skill). Both processes are specially important when output is poorly specified and the standardization of the production process is low -- this is the case of commercial computing. Generally speaking, labour is particularly efficient in problem solving, and physical capital performs better in repetitive or energy-consuming processes.

Because technical change has never stopped in commercial computing and this has meant that the mix of problems to be solved has been changing over time. The evolution has been more manifest in the "specialist-computer" interface than in the "user-specialist" interface. This process can be presented in terms of an initial lack of performance standards and a continuous revision of emerging ones, thereby preventing the consolidation of job specifications; and consequently job incumbents show very heterogeneous skills and qualifications. Moreover, employers are not frequently inclined to impose specific requirements, other than the evidence of problem-solving ability; or, to new entrants, a display of a capacity to develop such skills.

Besides, commercial computing is a growing sector and there are always new job openings that some firms fill with relatively well qualified ("experienced") specialists, while others select less qualified, or unqualified, ones. The latter involves a lower retribution at the beginning and facilitates the adjustment of the newcomer to the practices of the installation he joins.

It must also be stressed that many managers are very concerned about the interdependent marginal productivities of employees resulting from the nonexistence of well-defined standards in the interactions between the different tasks that are performed by computer specialists.

This goes a long way in explaining why some managers only recruit people that have never worked in computing -- as a manager said: new entrants have no "vices", meaning those practices not consistent with the way the installation functions, and hence no cost in eradicating them is incurred.

As a result, job categories, recruitment, redeployment and career patterns vary across firms according to the characteristics of the "internal market". Information on over one hundred Spanish computer installations belonging to different economic sectors, and regions, show that unless the firm's "internal market" restricts the scope for labour mobility and imposes barriers of entry, say, college degree for certain jobs, the opportunities for investment in skill-acquisition are many. For instance, entrants with only secondary education can expect to have access to any type of skill-acquisition. New entrants discover that problem-solving ability is the only requirement imposed by many employers. Many firms offer opportunities for junior staff to move to ather jobs with different content, partly because, as shown in section three, there is a great deal of interaction between tasks in computing.

Moving to the demand side, interviews, with computer specialists with different backgrounds and experience (in number of years and content of their jobs and career patterns) in commercial computing, showed that computer specialists are extremely sensitive to options for skill-acquisition and the opportunity costs, monetary and non-monetary, involved. A major incentive is technical change and the concomitant obsolescence of the know-how acquired. New technique s mean new problems and there is no place to learn them, but on the job. This should not be surprising if it is considered that computer professionals, in general, tend to be risk takers. They have chosen an occupation that is not well-known even by their practitioners and certainly there is considerable uncertainty as to their future. Consequently, these individuals are likely to pay a lot of attention to changes in opportunities for training.[1]

Thus, it is not unusual for a specialist to accept relatively lower wages in return for the option to work in an installation that uses new equipment. Other specialists invest in knowledge about the firm, or industry, through analysis and design of applications (sales, stock controlling, etc.) partly for nonpecuniary reasons - such as the preference for "non-machine-orientated tasks", and partly because they trade specialization in information processing, like systems software, for analysis of unser's demands which are more substitutable for other knowledge, which is the same as saying that the opportunity cost of transferring to another occupation is lower. Flexibility has, therefore, an economic value for computer specialists, since the content of specialization conditions the degree of flexibility (the opportunity cost of facing the uncertain future).

In addition, people interviewed were specially aware of how little they knew about computing when they first entered the field; how their career plans underwent modifications as they were accumulating information about the content of the jobs and about how well the tasks performed coincidded with their monetary and nonmonetary demands.

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1 Computer specialists' concern for technical change was very acute for many years. This is well summarized by the computer specialists' slogan "if it works it's obsolescent". Andrew M.Pettigrew, The Politics of Organizational Decision-Making (London: Tavistock, 1973), p.77.

More specifically, it must be stressed that tastes -- their non-pecuniary demands -- and the self-assessment of the abilities possessed change over time. And this, certainly, influences job and training choices and in particular the behaviour of people who leave computing and take jobs outside the field or vice versa. This is especially important for individuals whose first job ever is in computing, and regardless of their level of schooling.

These considerations may not be very relevant in a well-established occupation, the medical profession for instance, since new entrants can be far better informed, entry ports are few, and there are formal training certifications limiting the access to the profession. Computing jobs in Spain are not under such limiting influences; flexibility is enormous, and therefore to assume that there are such things as well-designed career patterns in commercial computing is unwarranted.

In short, computer professions in Spain use skill-acquisition as a decision variable due to monetary and nonmonetary considerations. Training opportunities and career patterns are varied and access to them open to all market wide, though not necessarily true for each firm since some "internal markets" limit intrafirm mobility in establishing barriers of entry for certain jobs. In other words, skill acquisition is a decision variable, a condition that is partly due to inter-firm differences in the breadth and depth of the training options.

3.7 The Breadth and Depth of the Skill Mix

In what follows I retain the division of computing skills into systems analysis, programming and operations. The options for the acquisition of productive skills can be aggregated into three groups, depending roughly, on who offers them: computer manufacturers, service bureaus and users. The distinction is economically meaningful because of the differences in (1) breadth and depth of the training they offer, and (2) turnover.

Generally speaking, manufacturers are those who offer more training geared to the technological aspects; service bureaux offer a broad scope of options for systems analysis and programming and, finally, users supply the widest range of options to learn about the actual working of user departments (sales, personnel, etc.). This specialization, however, is not always clearly defined. For instance, a large computer user may offer opportunities on the "technological front" that computer manufacturers cannot match. Thus, a user of a large real-time, teleprocessing, system may be using a configuration of computer peripherals, and user's imposed constraints, that may not be found elsewhere in the economy. Similarly, a manufacturer may be developing the design of a large, and complex, information system (payroll, accounts, etc.) for a user who is the first to computerize information in a given economic sector.

<u>I use the two classifications as shorthands for all the possible combinations of skills and options that are feasible in commercial computing</u>. Any of the groups of suppliers tend to offer the best opportunities for training in depth in the areas above cited and do offer broader, and shallower, training breadth in the remaining areas.

It must be added that commercial computing is practically open to anybody, as there is no generally accepted view of what should be the qualifications of new entrants in the field - similarly for promotions and changes from one "speciality" to another, say, from systems analysis to software programming. Training can also start off on simple tasks such as key-punching and progress toward programming in Cobol, for instance, and follow to systems analysis or, perhaps, towards specialization in software programming.[1] These possibilities are not necessarily available at every computer installation, or firm, but they exist at the market level.

The market for computer professionals allows for a large variety of paths in the acquisition of skills, as well as in the depth and breadth of these skills. There is also evidence of the importance of sociological and psychological considerations in the determination of what, and how, is to be learned. The preference for tasks involving, or minimizing, social intercourse is an example. These non-pecuniary aspects are very important in most cases, and an explanation of the optimal path of investment in computer skills cannot be offered in earnings functions, or in any other construct that is merely based on pecuniary (wages) considerations, as they do not account for non-pecuniary considerations.[2]

An explanation for the relevance of the non-economic variables can be offered following an economically reasonable interpretation.

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[1] Internal markets in commercial computing do not have a set of well-defined ports of entry except in those firms which do so as a matter of gneeral policy, irrespective of the characteristics of the department.

[2] The follow-up study of the introduction, and replacement, of computers in a British firm in A.Pettigrew, The Politics of Organizational Decision-Making, shows how resource-allocation decisions, and hence cost-effectiveness (and productivities) are decisively influenced by labour attitudes to nonpecuniary aspects of jobs when uncertainty and imperfect information prevail in a production process with variable coefficients.

New entrants know very little, if anything, about the tasks performed in any of the jobs they are initially offered. Often, they may be entering their first job ever. This means that some problem-solving is required to make the sequence of job choices that will lead to an acceptable skill mix. The individual has to find out whether the tasks he is performing come up to his initial expectations (demands). He accumulates information on economic, and non-economic costs and benefits. Considering that the process takes place under partial, and total, ignorance, the individual approaches work (commercial computing) with an open mind. He can alter his initial demand. To the extent that he faces multiple alternatives and the profiles of job incumbents are heterogeneous, it is reasonable to expect a large variety of job sequences. Furthermore, commercial computing may, or may not, be a long term commitment; often, people spend a number of years in the computer department and then move to a user department or management. This is understandable when one considers that the computer professional is trained in problem-solving that requires logical thinking and a great deal of decision making, particularly in systems analysis. These are skills important in other fields and the transfer cost is relatively low.

Thus, it can be concluded that: (1) a computer specialist can choose the breadth, depth and the sequence of training options; and (2) pecuniary considerations, and earnings in particular, are not sufficient to explain the variety of training paths chosen by computer specialists, nonpecuniary variables have also to be taken into account. The analysis of training has not been exhausted yet. The signaling value of trainees' performance, as a proxy for the economic value of a trainee, is an issue that must be studied too.

3.8 The Signaling Value of Trainees' Performance

Monitoring trainees' advancement is economically relevant, for it can be taken as a proxy, signal, for the trainee's capacity to solve problems, new problems in particular, since the latter group deals with different variables and relationships. This gives the employer information on employee's abilities and it facilitates a more productive redeployment. The most adequate (efficient) personnel may be assigned jobs with tasks which are less well defined and hence require more problem solving ability. In other words, employees' learning-by-doing is taken as a proxy for problem solving ability and also as a proxy for the generality, and hence versatility, of the employee's ability to learn and adapt to new technology. The latter factor is relevant in computing due to the continuous changes in technology, which often make specific knowledge obsolete and, at the same time, the development of formal training is discouraged.

Sometimes, certain skills may not always be available on the market, or even if they are, firms do recruit untrained people, though not necessarily without higher education. This allows employers to monitor performance and, simultaneously, to model employees in accordance with the work practices of the firm. This is important due to the often non-existent standards of performance in many computing tasks. Communications problems may appear as tasks are either partitioned in a sequence of inter-related obs or they are undertaken by a "pool" of specialists. In practice, it means that while someone develops a programme somebody else might test it, or the two tasks plus maintenance are done by the same individual. But if at some point in time such an individual is given another job, and another specialist has to assume the tasks, there is a considerable difficulty - inefficiency - in following the programme, especially if the conventions are not shared.

Having shown that employers and employees have a range of choices of technical designs and training opportunities with differing costs, the next section analyses the scope for training economywide, or to use a different label, the influence of the extent of the market on job designs and on the supply of training.

3.9 The Extent of the Market and the Supply of Training

Manufacturers train and specialize their personnel in accordance with the size of the market. Thus the largest market for real-time teleprocessing systems among "saving banks" is in Barcelona, and it is there where users have manufacturers with manpower highly specialized in the problems characteristic of these financial institutions.

If one takes a comparatively small market, for computers, Seville for instance, one can discover that a manufacturer only has a senior specialist because the number of clients in Seville plus the very few, if any, clients scattered over Western Andalusia require, on average, small number of hours of assistance from the manufacturer. The computer seller minimizes costs by sending someone from Madrid on the first plane if the problem is too complex or several major demands for help coincide. It follows that a customer in Seville is normally not serviced so well as the one in Madrid.

Generally speaking, manufacturers usually have a head office in Madrid that controls and assists regional offices, which, in turn, depends on a European chief office that is frequently located in Paris, or is under the control of the manufacturer central headquarters. This hierarchy broadly reflects the increasing availability of specialized manpower. A local, or regional, branch, has limited specialization, but for particular sectors that may be very important in the area, such as "saving banks" in Barcelona.

Manufacturers do not train people of a local, or regional, office on a new devise unless there is an effective demand to cater for. In fact, if an important user emerges, the manufacturer does not hesitate to bring a specialist from abroad whenever a qualified specialist is not avaialable in the area or even in the country. This often happened in the early and mid-sixties and it can still be observed in 1975. A pioneering computer installation can be an investment from the point of view of the manufacturer. The evolution of the market for commercial computing equipment has stimulated the involvement of manufacturers in the design of information systems for specialized users, such as hospitals. The design of the equipment can be made more efficient - more specific to the particular group of users - if the main parameters of the workload, or job stream, are known. Furthermore, this can be seen as an extension of a marketing strategy geared to offering the user a "ready-to switch-on machine", since it has always been the case that many users do not want to find themselves going through the design of the information system - the programmes that will make possible the computerization of the information.

The user attitude toward an in-house development of the information system is by no means uniform. Some consider that they know the best way to design the information system, while the actual computer, and the devices that complement it, are only a very secondary problem. This is particularly so when a user enters into the field of mechanized computation; after some experience is gained, they argue, one can begin to question the adequacy of the equipment in use. In other words, the computer is be cost-effective if it is manned efficiently, and this can only be achieved by user's staff who are well aware of both information demands and interpersonal and inter-departmental relations and hence they know the opportunity cost of affecting institutional practices.

Other firms prefer to get a system either specially tailored, or a standard design, supplied by the manufacturer or, often too, by a "service bureaux". Some users, finally, take a middle course, the manufacturer is asked to help in the development of the first few applications and once the user's staff begin to master techniques, the manufacturer's assistance in development is terminated. Within this third group, there is room for users that initially contract out the design and production of the information and, only after some time, decide to consider the possibility of in-house production of information.

The interviews suggest that the behaviour of users differs across regions and industries. Generally speaking, Catalan and Basque computer installations tend to be more self-sufficient from the very start.

The Public Sector and Andalusia show a major reliance on manufacturers, particularly the latter.

This affects the division of labour at the manufacturer's regional offices and, of course, at the user installation. Thus, a manufacturer in Seville is relatively more involved in the maintenance of basic applications, like payroll, for instance, than in, say, Bilbao, where the support to the user is mainly of a more specialized nature, software problems, for example. As a provisional explanation it can be argued that these differences relate to differential aspects of the labour force in the public sector and in Andalucia. More generally, there is no such thing as a Spanish labour market for qualified people; the low regional mobility, and the differences amongst markets such as Madrid, Seville, the Basque Country and Catalonia seem so important that what is valid for one is hardly relevant to another.

To summarize, it can be stated that the extent of the market, or the number of customers, bear a major influence on the users and manufacturers supply of training opportunities to their staffs, and indirectly to user staff - via the exchange of information between them. The extent of the market as well as its evolution over time affect training. These changes over time and to the effect of uncertainty upon obsolescence of computing skills must be considered as they affect the value of investments in technology (know-how and training)

3.10 Obsolescence and Training in a New Technology

Computer specialists are aware that technical change makes obsolete some of the know-how. The ability to programme in machine language that, at one time, was used in practically all areas became gradually obsolete, as far as programming user applications (payroll, invoicing, etc.) due to the progressive use of higher level languages such as Cobol and Fortran.

Nowadays there is a lower concern, and less anxiety, in being proficient in the newest device. The "profession" has slowly realized that the threat of obsolescence from new technology, not only new languages, tend to materialize after several years; for given the number of installations using the "old" technology, the new one is economically valuable in proportion to the number of users that adopt it. The more users adopting it, the larger the demand for people with the know-how to handle the new devices.

Besides, new technology often develops parallel to well-established tasks. For example, the development of real-time, and teleprocessing, has not done away with systems analysis. Regardless of the mode of production of the information, systems analysts still have to find out what information-output the user wants, and what are the information-inputs available or economically feasible.

What is likely to be affected is the breadth of tasks the systems analyst performs, and particularly the extent of the feed-back from specialists that translate the specifications into programmes and combine the resources to produce a cost-effective design. Thus, it is not surprising to find proficient systems analysts whose operational knowledge of computer hardware has not gone beyond what they learnt in the early sixties when systems analysis and programming were hardly differentiated.

There is another drawback in investing in the know-how of the very latest device, or vintage. Many of the problems to be solved are likely to change, and the scope for problem-solving is likely to be reduced once the device has been improved with the feed-back received from the first users. This can be exemplified with the IBM software packages, the first version, "release", is substantially improved over time. N wer releases are usually easier to handle -- they tend to present fewer problems, and a larger "library" of solutions is available.

It follows that while manufacturers' specialists must learn about each device they are supposed to repair and maintain, specialists working for users have to know only about the device they man; besides, they cannot master a device they do not operate, since training is, of necessity, on the job. Caeteris paribus, it may pay to change employer if the installations' practice is falling well behind the "average practice". It is at this stage when obsolescence begins to materialize.

Computer specialists interviewed were aware of the significance of the share — current and the trend — of the market by a given device, as a proxy for the value of the investment in new know-how and the value of know-how in older vintages. Their choices of employment, and career, were influenced by these considerations, and it was clear that not everyone was equally keen on investing in the newest know-how, specially when it involved changing employer or industry. While this section, has shown in micro-economic terms that there is a demand for training in new know-how, and that investors know that an opportunity cost exists, next section deals with the economy wide effects that innovations impose on users and employees who have invested in "old vintages".

3.11 Technical Innovations and Externalities

It is sometimes argued that if innovators produce positive effects that they cannot internalize, investment in innovation will be suboptimal.[1]

This may very well be the case, but it is not the complete story of commercial computing in Spain. Arrow contends that in the process of production of a new technology, learning-by-doing takes place unavoidably, and this results in a more cost-effective product, the manufacturer being unable to reap all the benefit from the improvement. His demonstration is beset of an economically dubious identification of costs, or "non-costs" such as learning-by-doing; the absence of a discussion of the possibility of an opportunity cost and risk in learning-by-doing, and the free (costless) character of the diffusion of innovation are far from satisfactory.

I contend in this section that it cannot be assumed that the diffusion of an innovation is a free good, or that it ought to be distributed at zero cost because the diffusion process cannot be separated from innovating. The process inevitably has an opportunity cost, and, at least in the Spanish commercial computing scene, the cost involved is not always negligible, though not necessarily superior to the benefit brought about by the improvement. Furthermore, benefits and costs do not appear to be affecting all users equiproportionately, so some redistribution effects are likely to take place.

The introduction of a new series of computers by a manufacturer leads to a gradual redeployment of resources away from the "old" line of products. Fewer specialists are available for the servicing of old products and a progressive run-down of spare parts stock takes place too.

1 "...the private marginal productivity of capital (more strictly, of new investment) is less than the social marginal productivity since the learning effect is not compensated in the market."
John K.Arrow, "The economic implications of learning by doing", Review of Economic Studies. (1962): 159.

The evidence gathered shows that, at least, those users purchasing a product shortly before it is beginning to be replaced are adversely affected by the rate of introduction of the new product, since the quality of the service provided by the manufacturer degrades progressively. After all, users of an old vintage are, to the manufacturers, similar to a small market; it is not economical to provide them with the same amount of resources that is made available to a large market. This economically imposed obsolescence may very well be smaller, in value terms, than the improvement in cost-effectiveness brought about by the new product. Even if this description of the innovative process be accurate, that is, costs are smaller than benefits, the idea of a costless diffusion of innovation would be untenable, unless one could show that the size of the costs involved is negligible — something that definitely runs contrary to the evidence collected.

Another consideration must be added. Contracts between manufactuer and user, and legislation on the minimum length of assistance of certain quality -- the latter being difficult to define and enforce, and certainly not without a cost -- can influence the speed of obsolescence, and the repercussion of innovation costs between manufactuerer, users of the newest vintage, and users of old vintages; legislation could put part of the burden on the innovator and manufacturer since the opportunity cost of the resources employed would be higher. The manufacturer would have to study the relative attractiveness of selling more or less new equipment while having to service users of old vintages. It follows that the pricing and servicing of the newest vintage would also be affected.

Evidently, these considerations affect also the value of investment in training by computer specialists. It is not obvious that technical change benefits those investing in it, and leaves unaffected investors in older vintages. In fact, the present value of training in old vintages falls as the new vintage is adopted by more and more firms. This does not necessarily imply that cost-effective improvements must be stopped. All it can be inferred here is that the interpretation of the innovation process as a free and costless one looks inadequate to discuss innovation and training processes in new skills in the Spanish commercial computing sector.

Conclusion

This chapter has shown that:

1) training in the most sophisticated skills in commercial computing consists of problem-solving;
2) skills can be obtained following different sequences of job choices;
3) training becomes easier as the range of variables is narrowed down and the functional relationships are better specified and constraints made explicit;
4) there are no generally accepted job designs, nor do job incumbents have a fairly standard profile; and
5) the market for computer specialists is a very competitive market due to ease of entry, lack of widely accepted recruitment standards, mobility and high elasticity of substitution.

I complement the discussion of training in commercial computing with a study of the Spanish market computer specialists. Whereas this chapter has used Spanish references in support of the general argument, Chapter 4 takes the Spanish case as the cnetral issue to be analysed.

Chapter 4

COMMERCIAL COMPUTING IN SPAIN

Manpower imbalances and training in commercial computing cannot be studied independently from computers. In previous chapters I have shown that the allocation of manpower is constrained by the choice of technique and, consequently, the analysis of the supply and demand for computer manpower -- the central issue in this chapter -- should be done in the context of the scope for choice of technique and the availability of other inputs. This is why I devote this chapter to commercial computing in Spain, and not only to the Spanish labour market for computer professionals.

I begin with an outline of the Spanish economy. A special reference is made to regional differences among the areas selected for this research. Having set the framework the market for commercial computers is analysed next. With this background information, and after having briefly discussed the Spanish labour market, the market for computer specialists and the supply of formal training are investigated. In other words, I show that: (1) major changes have taken place; and (2) little is known about them -- statistical data cannot be easily interpreted and are of dubious value for forecasting purposes.

4.2 The Spanish Economy

During the last fifteen years the Spanish economy has undergone profound changes. Spain was a predominanly agrarian country with a policy of industrial autarchy and interventionism established at the end of the Civil War (1939)[1]. During the late 1950's and early 1960's many government controls on resource allocation were gradually eliminated or relaxed; market forces and international trade were given an increasingly large role in resource allocation.

The stabilization plan of 1959 has become the conventional starting point of the new economic orientation, as well as of the ensuing rapid economic growth. In income per head terms, Spain went from ptas.38,504 in 1960 to ptas. 118,189 in 1974. During the same period, the Spanish National Income grew in millions of pesetas from 1,166,767 to 4,148,323. Data is in 1974 pesetas; (1 US $ = 58 pts.)

Because regional differences were, and remain, very important, four economically different areas were selected for this research: Andalusia (the city of Seville), the Basque Country (the provinces of Bizkaia and Guipuzkoa), Catalonia (the province of Barcelona) and Castilla la Nueva (Madrid). Table 4.1 provides statistical information on several major differences among these areas: population, migration, area, sectoral distribution of output and labour.

These areas were chosen because of:(1) the expected relevance of differences in the economic structure; (2) their unequal share of the Spanish market for computers, and (3) the financial and time constraints of the research.

[1] Autarchy, interventionism in production, and protection of the domestic market were already important before the Civil War (1936-1939). "A League of Nations study published in 1927 cited Spain as the country with the highest average tariff barrier in Europe." James D.Theberge, "Spanish Industrial Development Policy in the Twentieth Century" Chapter 2 of Spain in the 1970's. Economics, Social Structure, Foreign Policy ed. W.T.Salisbury and J.D.Theberge, (New York: Praeger Publishers, 1976), p.36.
For a critical analysis of the Spanish economy up to the early sixties: The International Bank for Reconstruction and Development, The Economic Development of Spain, (Baltimore: John Hopkins Press, 1963). The evolution of economic policies in Spain up to the late sixties is analysed by, Charles W.Anderson, The Political Economy of Modern Spain. Policy-Making in an Authoritarian System (Madison: The University of Wisconsin Press, 1970). For an up to date analysis: W.T.Salisbury and J.D.Theberge, op.cit.

Andalusia is mostly agrarian, with a low income per capita (relative to the Spanish average), a net outflow of migrants and a small share of the Spanish computer market.[1] The Basque Country is essentially industrial, with an important banking sector, a high income per head, a net inflow of migrants and the third largest computer market in Spain. Catalonia is very much alike to the Basque Country; but larger in area and population manufacturing is far more important than heavy industry, and it has the second largest computer market.[2] Finally, Madrid has the largest share of the computer market, and the labour market for computer specialists seems to be highly influenced by the practices of the central administration.

4.3 Computers in Spain

Electronic computers were first used for commercial applications in Spain in 1962.[3] It is estimated that 2,377 computers had been installed by January 1, 1976. This section tries to interpret the statistical information on computers installed.

Table 4.2 shows the numbers of computers installed every year since 1962. The rate of growth was above 30% during the sixties and above 20% since 1970 except for 1972 and 1975. Though as these figures do refer to a physical asset that has changed profoundly over time, it is difficult to accept that a time series from, say, 1965 to 1975 refers to a homogeneous category. The "first generation" computers of the early 1960's are essentially different from computers of the 1970's

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[1] The contrast between Andalusia and the rest of Spain is well documented in John Naylon. Andalusia (Oxford: Oxford University Press, 1975)

[2] An analysis of the Basque and Catalan countries in the context of the Spanish state is offered by Stanley G.Payne, "Regional Nationalism: The Basques and Catalans", Chapter 6 of Spain in the 1970's.

[3] In the early 1960's commercial computing in Spain was affected by import controls, and later by tariff barriers. Sellers of computers and conventional equipment (U.R.) were often unable to supply potential buyers during the 1950's and early 1960's.

Computers are not only more efficient, thd range of applications they can process has greatly widened and many new capabilities cannot be readily compared with earlier ones. Computer systems, as shown in Chapter 3, have many variables and the performance parameters and functional relationships change over time to an extent that newer vintages become different "machines". A monoprogramming, batch-processing, computer is essentially different from a computer that offers time-sharing facilities, processes on-line, in batch, or both. The technical evolution in this case is crucial from an economic viewpoint, since computers have gained so much in versatility and cost-effectiveness that they have become efficient substitutes to other processing systems in a very wide range of situations (applications). It is like saying that the latest computer vintages are "several machines in one": they can perform what a computer did in the early sixties, as well as several other types of tasks.

That is why historical trends are likely to be misleading. The evolution undergone by computers is reflected in the relative prices of inputs and outputs in computing, and consequently comparison over time is unreliable, especially among distant years. Price changes over time and their impact on demand and supply cannot be accurately predicted since technical improvements interact with market conditions. More specifically, there is no such thing as a price of "a computer" (or an application); computer systems consist of a set of devices that can be combined in variable proportions and, in recent years, they do not necessarily come from a single computer manufacturer.

The arbitrariness in using the same label for economically (and technologically) different vintages is usually compounded with the decision to exclude computer systems that are relatively small, in terms of performance capabilities, and purchase (or rental) price -- the so-called minicomputers and micro-computers.[1]

Moreover, the current characteristics of computers, and their share of the market are unlikely to remain as they are. It is a matter of guessing to discuss the future characteristics of computers and their impact on the market.[2] Nonetheless, it is fairly probable that major changes in commercial computing will result from the changing role of telecommunications in computing, microelectronics, and the evolution of the relative cost-effectiveness of centralized and decentralized computer systems.[3]

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[1] An example of such practice is found in Paul Stoneman, Technological Diffusion and the Computer Revolution. The UK Experience (Cambridge: Cambridge University Press,1976)

[2] It is difficult to take past trends on computer installed as reliable for projection when it is realized that "IBM holds and has held since the mid-1950's, about 70% of the world market for computers by number an value" Ibid., p.19. The same was true for Spain in 1973; IBM had 62.2% of the Spanish Market in value terms-- minicomputers being excluded. J.M.Pérez de Acha García, "Frenazo Informático", Doblón, November 1975, pp.9-13.

IBM's market share must be related to the pricing policy and to the cost-structure:

> "IBM's 1971 manufacturing costs were of the order of 22% of gross revenue. It is the difference between these costs and revenues which gives IBM its strength; indeed, we have here what many specialists think is the widest across-the-board margin between cost price and selling price that exists in any company in the entire field of manufacture". Rex Malik, And Tomorrow ... The World?. Inside IBM, (London: Millington, 1975), p.173.

[3] "Many companies in the industry have come to accept that the saddleback [the relative stagnation of the market for medium-sized computers, the seat of the saddle, and the boom at both ends -- in large and specially small and mini machines] is part of the structural shift in the business. Behind it, are the two facets of distributed processing: soaring demand for small stand-alone systems of various types, and the combination in 'communications systems' of big 'host' computers with large numbers of geographically dispersed small/mini intallations or even just intelligent terminals." Christopher Lorenz "Contrasts in Riding on the 'saddleback'," Financial Times, March 25, 1976, p.14.

"As the scale of integration of circuits increases and prices fall, the manufacturers of say, communications equipment finds that his design becomes more dependent on the design of the microcircuits which he ((contd. over))

Another very important aspect of the evolution of the computer market is the growth and diversification of suppliers of computer services independent from computer manufacturers; among them, service bureaux, used-computer brokers, computer-leasing companies, time-sharing vendors and software firms. Changes in the cost-effectiveness in the provision of specific services and the widening of the market are among the relevant variables in the explanation of the mergence of the range of specialized suppliers of services. However, there is not an analytically satisfactory theory of horizontal disintegration and, therefore, it is not possible to tell the future evolution of the computer market. Once again, relative prices and cost-effectiveness are the relevant, and uncertain, magnitudes that will influence the future characteristics of the market for commercial computing.

Finally, the sectoral distribution of computers has changed over time, presumably due to differences in cost-structures and in the characteristics of the information to be processed. Table 4.3 offers evidence for the period 1966-70.

This section indicates that data on computers installed is not reliable for accurate predictions, and the more so, the larger the level of aggregation. Besides, time series are less reliable the longer the period considered. This limitation can be summarized in the following way: statistical data cannot be unambiguously interpreted because an understanding of demand and supply of computers is lacking. That this is so, it is shown in the next section.

((3 Contd.)) buys (normally) from the U.S. In many cases, the circuits also account for more and more of the manufactured value of his product.... the microcircuit maker finds it much easier than before to 'integrate vertically' into the manufacture of complete equipment. This is why U.S. semiconductor companies have gone into complete calculators, watches and computers" C.Lorenz, "Thumbnail Computers", Financial Times, June 9,1976.p.19

4.4 The Demand for New Computing equipment

The information accumulated from over one hundred installations shows that some firms introduce new aquipment as soon as it is available in the market; others never adopt a new piece of equipment before they have seen the new device working satisfactorily in several user environments. Entrepreneurs are always aware of the existence of different opportunity costs among the feasible courses of action. What is by no means clear is how to estimate these costs, and whether or not all entrepreneurs have the same demand function. This section shows that the first question has not a unique answer because trade-offs are not fully understood. As for the second question, the evidence collected in this research shows that entrepreneurs differ in their cost-structure (direct and indirect costs) and in their risk attitudes; in short, production and demand functions for computers differ among entrepreneurs.

The demand for new equipment takes place when the opportunity cost of retaining the one in current use exceeds the cost of buying a new and more cost effective design.[1] A new computing device cannot be adoquately defined without a reference to the number of users -- the extent of the market. The potential buyers know that manufacturer's assistance (specialists trained in installing and repairing and the availability of spare parts) depends on the size of the clientele - current users. This is not a minor consideration because users are aware of the fact that computing devices cannot be efficiently installed by specialists who are unfamiliar with the equipment. Each new design presents new problems that have to be solved in the process of making it run smoothly. The

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1 In recent years a used-computer market has emerged in Spain. Specialists working in installations that were using a combination of new and second-hand computers were interviewed. The purchase of used equipment has advantages and disadvantages, not necessarily different from those encountered in the purchase of new devices. For example, in both markets technical assistance ("back-up") is a relevant problem. How important is this market nowadays, and how it will evolve, is difficult to forecast. In addition, current statistical information does not account for this segment of the market.

installation of the first unit of a new device takes more resources, manpower and computer time for testing than subsequent ones.

Users behaviour differs because their opportunity costs are not the same. A higher cost of installation is sometimes compensated by the saving derived from introducing the more cost-effective method at an earlier date. The risk factor is also important; it is not easy to predict how long it will take to get the new equipment working normally, nor can it be reliably predicted the rate of introduction of the new equipment on the market, and hence the quality of the assistance from the manufacturer may remain at a low level for a long time.

A very well-known example is the introduction of the IBM "360" series and the improvement of its operating system over time. Those installations that started with the "release-0", the first version of the operating system, had many more difficulties than installations starting with improved versions which besides, were installed by specialists already familiarized with the problems and solutions likely to be encountered. Similarly with firms that are first users of a new manufacturer or device. In return, first users are often given special conditions; manufacturers offer lower prices or a more comprehensive assistance, such as assigning a specialist to the user installation on a full-time basis until the new device works satisfactorily.[1]

There was not a single person among those interviewed that had participated in the process of selection of new equipment that was not aware of trade-offs between early and delayed purchase of new equipment.

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[1] To the extent that first users face risks, and given that manufacturers draw some benefits, such as training for their specialists, price discrimination is less than obvious when dealing with user innovators.

Cost considerations, company prestige and employees perceived interests,— such as the importance of being at the 'frontier of technology'-- were relevant, though not always all these factors played a significant role.[1] From the evidence gathered it is not possible to qualify the relative importance of the variables affecting the choices on new equipment. The observed inter-firm differences cannot be generalized to the market as a whole. However, one observation was consistent throughout: installations that were highly efficient, according to the specialists interviewed, were essentially concerned with cost-effectiveness, and becoming first users was a last resort choice; where prestige and employees interests (narrowly defined) prevailed, there was a more favourable attitude toward innovating as soon as a new device, or a newer vintage, was available on the market.

To summarize, users differ in their attitudes toward innovation and the evidence collected does not suggest a theory of demand for computers. Similar evidence, and conclusion is produced in the discussion of the supply of new equipment.

4.5 The Supply of New Equipment

The introduction of a new product, or the entry of a new manufacturer on the market requires an investment in training salesmen and technicians. New computing equipment is never supplied without manufacturer's assistance during the process of installation and testing. Manufacturers provide information on the new equipment to their own specialists, but it is often very incomplete. A decisive proportion of the specific knowledge -- problems of implementation and solutions -- on the new equipment can only

[1] The evidence collected in this research is consistent with the results from a case study of a British installation analysed in A.Pettigrew, The Politics of Organization Decision-Making. Decision making on technical choice is seldom based on efficiency alone. Cost-effectiveness is the usual approach. The problem is that decision makers do not face the same cost-structure (direct and foregone).

be learned by actually being involved in the process of setting them up.

The differences among manufacturers in the way they train their own specialists, and the practices toward first users, specially price reductions and a more comprehensive assistance ("backup") can be explained in terms of the rate of growth of demand and the amount of risk, or "insurance premium", relevant to sellers and buyers.

Computing equipment in general, and new devices in particular, cannot be easily evaluated; their performance depends, as shown in chapter 3, on the interacting devices and the workload. A major installation usually has the means to estimate performance of new devices, even if imperfectly. Their acceptance of a new device becomes an asset for the salesman of that manufacturer who cites the big user acceptance or shows the new installation as a guarantee to prospective buyers. So, the manufacturer is often willing to offer better deals to purchasers other than first users.

Computer sellers often adjust prices according to the bargaining strength of the buyers. The evidence of this study shows that certain new users with a predominantly cost-effective approach, cost-minimization for an output with fixed specifications, tend to get a better deal than those primarily preoccupied with prestige and employees obsolescence of training. It was realized that the former tend to be very precise about datelines, penalty clauses and manufacturer assistance during the change-over period. The latter were considerably vague about the condition of the contract. These observations indicate that:(1) a significant part of the cost of technical innovation in Spain was, and still is, financed by relatively inefficient installations;and (2) the inefficiency is greater, the higher the rate of growth of the demand for computers. Whether the returns in terms of prestige and employers protection against obsolescence compensate for the losses in efficiency cannot easily be estimated; since, for instance, prestige is a consumption and sometimes an investment. Clients can be favourably impressed by the latest technology of a supplier, though this is an empirical question, for clients may care about cost-effectiveness and not be very impressed by the relative novelty of equipment. So far, I have shown in this chapter that: (1) both the Spanish economy and the market for computers have undergone profound changes during the recent past; and (2) that heterogeneity in inputs and prices prevails---a situation that is further complicated by the evolution of the labour market.

4.6 The Spanish Labour Market

The Spanish labour market of the 1970's is essentially different from what it was during the 1950's. The interventionism of the years following the Civil War began to evolve in the late 1950's. The "Ley de Convenios Colectivos" of 1958 was the first major step towards a less controlled labour market: collective bargaining replaced labour regulations in the determination of wages and other aspects of employment of manpower.[1]

Labour legislation and the working of the market were constrained by political considerations. The authoritarian structure of the political regime did not favour labour bargaining since that was bound to lead to unionization outside government control. Such a precedent would have been a Trojan horse for the authoritarian political system. The substitute that was devised consisted of a basically bureaucratic trade union structure (La Organización Sindical). Strikes were illegal, and so were

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[1] Labour bargaining is not totally free from government intervention. In fact labour agreements (Convenios) have to be approved by government before they can become operative.

Information on the evolution of the Spanish labour market, and to a smaller extent, on the educational system of Spain is offered by Morris A. Horowitz, Manpower and Education in Franco's Spain (Hamden, Connecticut: Archon Books, 1974). This book offers conclusive evidence on the profound changes undergone by the Spanish labour market.

redundancies (except in certain very extreme cases); job security was what a paternalistic political regime offered to employees.

In recent years actual bargaining practices seem to reflect more and more relative scarcities. Strikes are increasingly frequent, and have become legal in 1976. Employers right to make people redundant seems less likely to be recognized in the near future; organized labour is increasingly more strong and, it appears, that they are against any relaxation on the current limitations to the employers right to make employees redundant. This changing scene, especially the changing role of unions and their bargaining power, reduces the predictive value of past statistical data on the labour market.[1] Government interference in the labour market is still important and likely to remain so.

An important instrument of governmental intervention is the legislation on minimum wages, first introduced in Spain in 1963. The effects of minimum wage laws on wage determination are more wide-ranging in Spain due to the existence of several, not one, minimum wages; for there is an interoccupational structure of minimum wages, Table 4.4, that divides the labour force in twelve occupational grades, each one with a minimum wage.

The repercussion of such structure on the heterogeneity of occupational classifications is likely to be important, partly, because of the limited scope for private bargaining. A Fixed structure of minimum wages cannot be expected to reflect relative scarcities; the adjustments required when scarcity prevails leads to occupational upgrading for certain tasks if the wage adjustment is larger than what either government regulations, or the practices of the "internal market" permit.

[1] The death of General Franco in November 1975 opened a period of political uncertainty; it is a matter of guesswork to predict the outcome.

The relevant consideration here is the realization that a multiplicity of variables influence the actual composition of occupational classifications. Unfortunately there is no way, at present, to estimate the relative importance of the variables involved. This situation affecting the entire labour market is particularly relevant in commercial computing, due to the rapid growth of the demand for certain skills.

Table 4.4 exemplifies a characteristic of most Spanish labour statistics. Data is highly aggregated and taxonomical criteria are not discussed. Besides, a careful observation of table 4.4 shows an inconsistency: educational background is used to identify some, not all, occupational groups.

It must be recalled that the analysis developed in Chapter 2 suggests that highly aggregated data on manpower is of dubious usefulness, since the level of aggregation chosen will influence the value of the elasticities of substitution among different labour groups, thus reducing the reliability of estimates of shortages and adjustment lags.

So far, I have only considered two major problems: (1) the degree of government interference; and (2) the analytical weaknesses of existing occupational classifications. The conclusion to be extracted points to the poor understanding of the process of resource allocation of labour. A conclusion reinforced by migrations and the evolution of the sectoral distribution of labour, as shown in Table 4.1 and Table 4.5.

From all these considerations it is reasonable to state that the Spanish economy, the labour market, and the market for computers, have undergone profound quantitative and qualitative changes during the last twenty years -- changes that are hardly understood and a similar conclusion is reached analysing the labour market for computer specialists.

4.7 Manpower Shortages in Commercial Computing

Commercial computing adds the nonexistence of a widely accepted occupational classification to the theoretical weaknesses of the concept of manpower shortage and the limited relevance of trends in wages as a measure of labour imbalances; a situation further complicated by the poor understanding of the recent evolution of the Spanish economy, the computer market and the labour market. In other words, the demand and supply of computer specialists has not yet been specified satisfactorily. The evidence collected in this research indicates the existence of considerable differences inter-firm, sectorally and regionally. In what follows, an analysis of perceived differences is offered.

I mentioned in Chapter 1 that interviews are the empirical cornerstone of this thesis. Here I offer a breakdown of the characteristics of the people interviewed. Of the 107 persons interviewed, all, but two, were males.[1] The regional distribution was as follows: Andalusia (15), the Basque Country (14), Castilla la Nueva (20) and Catalonia (58). On average, interviews lasted between two and three hours, each person being interviewed only once.

Educational backgrounds were as follows: Secondary and primary education (19), higher education (70) and unreported (38). The latter group is explained by the fact that it was not helpful to press for information on that score, as I often perceived a certain reticence on the part of the interviewee. Probably because higher education degrees

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[1] Males are in overwhelming majority because that reflects the actual situation in Spanish commercial computing, although it should not be inferred that female participation in this field is as low as two per cent. Available evidence indicates that females are not evenly distributed among the different tasks in commercial computing: they predominate in those tasks that resemble traditional office work and represent and increasingly lower proportions as the tasks become more and more sophisticated.

often confer a status image among many Spaniards — a belief confirmed by many interviewees.

Those interviewed had the following employers: computer users (49), service bureaux (22), manufacturers and distributors of equipment (22) and had left computing (4). As for work experience before joining computing (45) and interviewees that had more than one employer while working in computing (34)

Inter-firm differences are many and important. Aggregate averages cannot produce a valid estimate of optimal input proportions. Cost-structures differ among firms, and so it happens with the techniques selected.[1] More specifically, it has been found that job redesign, hiring, training and promotion standards are usually policy variables that decision-makers use in different proportions, thereby making the concepts of (aggregate) manpower shortage, and occupation, almost empirically useless.

Occupational heterogeneity in commercial computing is not a disturbance element but the very result of an on-going process of adjustment to a rapidly growing demand for certain skills.

True, the evidence shows that earnings of highly specialized computer specialists have risen faster than the average increase in earnings of labour.[2] What is disputed here is not this evidence but the empirical

[1] Unpublished studies on inter-firm differences in the structure, and utilization, of computer installations support the existence of great disparities. Some evidence for the 1960's is analysed in: Asociación para el Progreso de la Dirección Encuesta sobre la Utilización de Ordenadores en España",(Madrid, 1972).

[2] No reliable information on earnings of computer specialists has been published. However, consultation of private estimates based on samples of the market does confirm this opinion widely held among computer specialists. The evidence shows that trends are often irregular. A very interesting observation is that the relative worsening of earnings of computer programmers during the last four or five years coincides with the gradual simplification of programming.

value of trends in earnings of computer specialists as a measure of shortages and lags in the adjustment process. So long as entrepreneurs use in varying proportions wages together with other variables, in response to a growing demand for computer specialists, it is not logically correct to assume that the evolution of wages gives a precise, an unambiguous, estimate of manpower imbalances. Such a multiple variable adjustment is, after all, what makes jobs so heterogeneous in commercial computing, thus precluding the obtention of homogeneous (aggregate) occupational classifications.

What has been said at the firm level must be combined with sectoral differences. In this context too, cost-structures and in particular, the characteristics of the output (information) demanded vary from one sector to another. Such differences tend to be reflected in the practices or 'technique' prevailing in the "internal markets", as well as in the characteristics of inputs, human and physical, used.[1]

At the regional level, the differences in the composition of the labour supply strongly influence the characteristics of the manpower used. The evidence gathered is not systematic but, it is highly suggestive. The composition of (local) educational output was reflected in the relative preponderance of job incumbent with given degrees. For instance, Barcelona has a large output of graduates in business, economics and engineering fields and these graduates predominate among highly specialized computer specialists in Catalonia. Madrid also shows a similar pattern, although engineering and sciences are probably the most important. Guipuzkoa has few of the above graduates in computing relative to the number of scientists. In this last case the openings for business

[1] Recent privately circulated studies show inter-sectoral differences in ways similar to published data for 1970. Spain. Presidencia del Gobierno, La Informatica en España (Madrid: B.O.E., 1973.)

graduates in commercial computing, a situation partly due to the low attractiveness of commercial computing which, in turn, is probably a result of the low standards of commercial computing in Andalusia: the computer is predominantly a prestige item, an information system which has taken over routine work and it is not frequently approached with a view of efficiency.

Generally speaking, the variety of college backgrounds found among computer specialists, and the regional differences, confirms that the connections between occupations and type of college education is very loose. All it can be said is that college degrees are wanted in commercial computing to the extent that they train labour in problem solving. In any case the question of formal training in commercial computing must be discussed in greater detail. But before dealing with formal training in commercial computing I analyse the Spanish educational system.

4.8 The Spanish Educational System

The Spanish educational system has altered decisively during the last two decades. Until the fifties primary education, and to a lesser extent illiteracy, were the dominant features of Spanish education. Secondary and tertiary levels were elitists and attended by a minority of the population of schooling age. The structure of the educational system was rigid; at all levels there were several educational paths, sometimes without an option to transfer from one to another (in much the same way as the eleven-plus in the United Kingdom). Higher education consisted of a number of specialities with practically no scope for specialization in a combination of courses taught in different "facultades" or "escuelas tecnicas".

The educational philosophy and the structure of the system had their legal origin in the education act of 1843 (Ley Moyano). Many changes and extensions followed that law in the course of the years, but it was not until 1970 that a comprehensive legislation was introduced (La Ley General de Educacion).[1] This was a response to;(1) the expansion of the enrolments, specially at the secondary and tertiary levels; (2) the demand for more flexibility in the educational system; and (3) the changes in the role of formal education as perceived by individuals and the government.[2]

The expansion in the number of students in secondary and tertiary education must have affected the labour market more than marginally. The relative weight of such change cannot be fully ascertained from the available evidence. The increase in the demand for education does not seem to be due only to investment motives. This interpretation is based on the fact that educational enrolments began to grow during the 1950's, whereas the rapid economic growth, and the expansion of the demand for manpower started in the 1960's. Furthermore, it is not obvious why enrolments leading to certain degrees grew more than others, nor can the inter-university differences be explained, except by noticing that universities differ in the variety of degrees they offer; an important consideration in a country where students tend to enrol in the nearest university, or else go to Madrid.

Section after section, in this chapter, the same conclusions are reached: (1) changes have been very important, they are not marginal ones,

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1 The White Paper that preceded the 1970 legislation offers a very clear and wide-ranging exposition of the Spanish educational system and its evolution (specially) during the 1960's. Spain Ministerio de Educación y Ciencia, La Educacion en España. Bases para una Política Educativa, (Madrid: B.O.E. 1969)

2 Inadequate financing and opposition to the proposed educational reform have influenced the actual reform of the educational system.

firms have different 'production functions' and do not face the same prices for (heterogeneous) inputs; (2) the analysis of changes are difficult partly as a result of the limited information available, and partly, because of theoretical limitations; and (3) past trends, when projected into the future, are often only relevant for periods of one or two years.

Despite the very limited reliability of the existing background information, it is useful as a framework for the analysis of formal training in commercial computing in Spain.

4.9 Formal Training in Commercial Computing in Spain

I have not included the analysis of formal training in commercial compyting in Chapter 3 because of the singularity of the Spanish case.

Computing became a differentiated field in centres of formal education in many countries during the sixties. A variety of degrees were gradually developed with different emphasis on programming, languages, numerical theory, business and scientific applications, physics, engineering design etc. Courses, specially on programming, were supplied by employers, firms specializing in formal training in commercial computing, and institutions of formal education (already supplying courses on other subjects).

The degree of adequacy of courses to tasks performed on computing jobs could not be precisely determined, since technical change, and interfirm differences, prevented the design of courses closely related to the problems actually solved on the job. In fact, that was a reflection of something already discussed in Chapter 2: courses appeared when it was technically feasible, and economically efficient, to develop sets of formalized problems and solutions which resembled more or less closely the activities performed at work. The accent was, and remains, on problem solving.

This is the case of countries such as the United Kingdom and the United States. Spain did also start formal training in the 1960's. Suppliers of formal training were either computer manufacturers or computer-user firms. According to the evidence collected, the quality of formal training greatly varied from one supplier to another. This situation fostered the demand for government intervention: the state ought to offer formal training in computing.

Some universities began to teach on some aspect of computing around the mid 1960's as part of old-established degrees such as mathematics in the Universidad (Complutense) de Madrid. Legislation on degrees in computing did not materialize until 1969. Unfortunately, the degrees on computing established in 1969 by the Spanish Ministry of Education and Science were defined according to a questionable classification of occupations in commercial computing: a classification that was not generally used by employers and employees.

In fact the decision was also questionable on the grounds that tasks in commercial computing were in state of rapid evolution. For even if the chosen occupational structure had become adopted by the market, the life of such classification would have been very short as technical change profoundly altered the content of tasks; programming, cited in Chapter 3, is a case in point. In other words, a legislation aimed at clarifying the signal value of formal training became a source of confusion.

The 1969 legislation was opposed by institutions of higher educations as well as by computer specialists. The result has been new legislation modifying the structure of degrees, as well as their status within the educational system. As the new regulations have not yet been fully developed it is not possible to compare them with the superseded ones. However one thing is clear, the new degrees are not intended to reflect an occupational classification.

4.10 Conclusion

Commercial computing, and the market for computer specialists, in Spain are going through many non-marginal changes -- a process that started in the early sixties, when computers for commercial purposes were first used in Spain. An unambiguous specification of the functional relationships involved cannot be produced; the major problem is the lack of a theory of choice of technology and technical innovation under uncertainty. Empirical evidence shows that investors in this field differ in their attitudes, and in the actual choices of technique and training,

The limitations of the empirical analysis are complicated in the Spanish case:(a) by the profound changes occurred in the economy and the labour market;and (b) by regional differences. Chapter 5 deals with the computer market in Catalonia because:(1) it is the second largest computer market in Spain; (2) the Catalan market for highly educated manpower has been researched to a degree not matched for other regions or for Spain as a whole; and (3) regional differences are important in the understanding of computing and the market for computers specialists in particular.

Chapter 5

COMMERCIAL COMPUTING IN CATALONIA

5.1 Introduction

Strong inter-regional differences suggest that a study of a regional market is warranted. The size of the computer market and the information on the labour market are the decisive reasons behind the choice of the Catalan market. The structure of this chapter is similar to that of Chapter 4 since, regardless of the size of the market, training and manpower imbalances in computing can only be efficiently analyzed as part of the study of choice of technique (and inputs).

In this chapter I deal with the Catalan economy, the market for computers and computer services, the labour market for highly educated people and training and manpower shortages. Next, I discuss types of formal training and certification, and finally, the main findings from the other markets are investigated.

The chapter shows the interaction between information acquisition (training and otherwise) and the transparency and competitiveness of markets in computing. Economic units acquiring information in a heterogeneous and rapidly changing environment are aware of the limitations of aggregate data and the relative efficiency of information based on a small number of well-known cases.

5.2 The Catalan Economy

Catalonia has a very singular economic structure. Secondary and tertiary sectors produced 94.3% of the gross value added in 1970. Raw materials and minerals have been practically non-existent; a constraint that partly explains the relative preponderance of light industry. Economic growth and the evolution of the composition of the industrial output have been dominant features during the last fifteen years. Chemicals, metallurgy and food processing are among the most important, and rapidly growing, sectors. Traditional industries, such as textiles, are becoming relatively less important.[1] Table 5.1 offers a summarized comparison between Catalonia and Spain.

The choice of Catalonia as a unit of analysis should not obscure the existing interprovincial differences. Barcelona province, and particularly Barcelona city and its metropolitan area, produce a very large proportion of the Catalan industrial output -- a situation more than a century old. The province of Tarragona has developed around the provincial capital a very dynamic chemical industry, which is likely to be strongly affected by the oil discovered off the coast of Tarragona[2]. The tertiary sector, specially tourism, is very important in the three coastal provinces: Barcelona, Gerona (Costa Brava) and Tarragona. Lerida province is predominantly agrarian.

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1 Narcis Serra, Antoni Flos and LLuis Artal, "Sobre L'Estructura Industrial Catalana," Banca Catalana 31 (December 1973).

2 Recent oil discoveries off the coast of the province of Tarragona seem to indicate that a sizeable proportion of the Spanish market could be met with the oil likely to be found under the sea in a wide area, between the Ballaeric Islands and Catalonia. Avui, June 3, 1976, p.11.

The economic structure of Catalonia is, therefore, dominated by the secondary and tertiary sectors. In addition Table 5.1 shows that Barcelona and its metropolitan area have the largest concentration of (industrial) production and population, a feature important in the understanding of the labour market. However, before dealing with manpower issues, I analyse the market for commercial computers in Catalonia.

5.3 The Market for Computer, Minicomputers and Computer Services

On December 31, 1970 there were 177 computers installed in Catalonia. The subsequent evolution is not known, nor is it likely that the Catalan share of the Spanish market has remained unchanged during the last five years.[1] The reason being that small and medium size firms predominate in Catalonia and they are the ones that can opt for a minicomputer instead of choosing a small computer. According to unpublished data, the minicomputer market is considerable.

The Catalan market is also developing a computer-used market, as well as a market for computer time (sellers being mostly installations with underutilized computers). Service bureaux, offering a full or a limited range of computer services, have existed since the early sixties and they have consolidated their position in the market, despite the strong competition among them from sellers of computers and minicomputers.

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1 The figure of 177 computers has been obtained by dividing the number of computer specialists in Catalonia, 2722, by 15.37, the average number of specialists per computer. Catalonia had the 23.5% of computer specialist in Spain, according to the 1970 census on manpower in commercial computing. This information is published in La Informática en España.

On the evidence collected during this research, competitiveness in the Catalan market for computers is only comparable to that of the Basque Country in spite of the fact that the latter is a smaller and less diversified market.[1] This observation is all the more important when it is realized that a similar conclusion emerged for the computer specialist market.

Such coincidence in the degree of competitiveness in both computer and manpower markets is not surprising when it is realized that decision-makers that aim at a cost-effective choice of an information-processing system evaluate the interacting specifications of inputs and outputs (technique). This amounts to saying that decision-makers analyse the markets of inputs in cost-effective or 'competitive' terms.

The competitiveness found in commercial computing is also a distinctive characteristic of the Catalan market for highly educated people, as it is shown in the following section. This competitiveness, however, is not taking place in a market for homogeneous inputs (physical and human) that share the same prices, but it occurs among heterogeneous inputs facing multiple prices.

5.4 The Labour Market for Highly Educated People

This section is based on studies of the Catalan labour market by J.Crespan Echeyoyen et al.,[2] J.Jané Solá,[3] J.A.Marcos Alonso,[4]

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1 Given the rapid and continuous change in relative cost-effectiveness among alternative choices as to the processing of information, projection of past trends are unlikely to prove accurate. Moreover, all consulted firms that forecast the evolution (expansion?) of the computer installation are fully aware of the need for yearly revisions because of uncertainty which materialized in unpredicted development, and events that occur in a way different from what was assumed in the forecasting exercise.

2 Javier Crespań, Echegoyen, Jesús A.Marcos Alonso and Tomás Moltó García El Mercado de Trabajo del Personal Técnico y Altamente Cualificado a Traves de la Prensa (Barcelona: Colegio Oficial de Ingenieros Industriales de Cataluña, Gabinete de Estudios, 1974).

3 José Jané Solá, El Problema de los Salarios en España (Barcelona: Oikas-Tau, 1969); "Los Salarios en Cataluña. Estructura y Evolucion de los Años Sesenta." in le Economia de Cataluña Hoy (Barcelona: Banco de Bilbao,1974)

4 Jesus A.Marcos Alonso, Los Ingenieros entre el Pasado y el Futuro (Barcelona: Laia, 1974).

E.Pinilla de las Heras[1] and A.Sáez.[2] The evidence produced by these works indicates that the Catalan labour market has changed profoundly since the 1950's; that transparency and competitiveness have become important and Barcelona and its metropolitan area set the pattern for the Catalan labour market.

The importance of the net inflow of migrants seems to be particularly important among the unskilled and low-skilled levels. For the highly qualified manpower (with tertiary education) the mobility seems to be mostly intersectoral and inter-firm; a characteristic that has emerged in conjunction with the general move toward a less controlled labour market since the late 1950's.[3]

The information on the labour market has always been limited and unreliable specially in relation to earnings. Legislation on collective bargaining and minimum wages add a degree of interference that is not always detected and separated out from other considerations.[4]

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1 E.Pinilla de las Heras, Immigració i Mobilitat Social a Catalunya, 3 vols. (Barcelona; ICESB, 1973 and 1975).

2 Armand Sáez, Población y Actividad Económica en España, (Madrid: Siglo XXI Editores 1973).

3 A.Sáez, "La Actividad Económica de los Catalanes La Evolución de le Población Activa de Cataluña. 1950-70", La Economia de Cataluña Hoy, pp. 23-97
The importance of the flow of highly educated migrants into the tertiary sector in contrast with the very small influx into industry is open to reservations when the same research stresses that "the likely figures for occupations in the tertiary sector cannot be known with an error inferior to 20%", Pinilla de las Heras, Immigració i Mobilitat Social a Catalunya, 1: 14

4 Jané's research, cited in footnote 6, p.15, shows how little is known about labour markets in Catalonia and Spain. There is evidence of a growing gap between wages and earnings, as well as between actual deals and the "convenios collectivos" (government-approved labour agreements). In short, conclusions have to be tentative when dealing with specific segments of the labour market, such as the market for highly specialised computer specialists.

Despite these constraints, and the rapid change of the industrial structure of Catalonia, the labour market for highly educated people appears to have gained transparency. Highly specialized jobs defined in terms of the problems to be solved, have become more specific and so it has the background education demanded by employers. The opposite tendency has developed among managerial jobs, where different educational backgrounds are seen as better substitutes than was the case a few years ago.[1]

A very important trait of this market is the apparent senstivity to market trends as reflected by employers changes in the composition, and educational background, of the job offers during the different phases of economic cycles.

During a recession employers do not only demand better educational backgrounds for similar jobs, but that they also tend to alter the composition of the demand in favour of manpower with sales and marketing, related background.[2] This is economically reasonable since recession periods usually amount to unused productive capacity, or slack demand. This throws further doubts on manpower forecasting on the basis of the composition of manpower demanded: predictions can also go wrong because firms redesign their production processes in accordance with the state of the market. The redesign affects the proportion between "production" and "sales" and consequently affects the amount, and characteristics, of the manpower demanded.

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1 J.Crespán Echegoyen, et al., El Mercado de Trabajo del Personal Técnico, This is particularly relevant to this research since it is centred around the analysis of the substitutability between graduates in civil engineering and other graduates -- and civil engineers constitute a sizeable proportion of graduates that work in commercial computing. In fact it shows that substitutability is particularly important for poorly specified jobs, such as managerial activities. The study used the job adverts which appeared in La Vanguardia Espanola, a Barcelona daily newspaper, something that makes the conclusions very relevant for the computer labour market; since people working in commercial computing consider the information contained in the job adds published by that paper as a proxy for the state of the market.

2 Ibid., Chapter 4.

Attempts to estimate manpower shortages are unlikely to produce reliable results when it is considered that employers are making adjustments of the labour force employed that do not necessarily reflect the relative movements of earnings. Another aspect of the problem is the ignorance as to the relative opportunity cost of using different mixes of adjustment variables, or to put it differently, firms face neither the same "micro-production function" nor the same relative prices.

For the purpose of the present investigation, the relevant conclusions are: (1) the profound change of the market for highly qualified specialists since the late 1950's; and (2) the competitiveness of the market. With this background information the next section deals with training and manpower shortages in commercial computing in Catalonia are analysed.

5.5 Training and Manpower Shortages in Commercial Computing

The Catalan market for computer specialists is very competitive. "Internal markets" are important, but entry is generally open to individuals with practically any background. Even if some "internal markets" specify minimum educational requirements for highly specialized tasks, tertiary education is usually a preferred background rather than a pre-condition for eligibility to the job. (This question of formal education as a background for job applicants is dealt with, in greater detail, in the next section.)

Investors in training, employers and employees, are aware of: (1) the existence of multiple trade-offs; and (2) that they differ inter-firms. Say, for instance, employees know that firms do not coincide in the characteristics of the training they offer. It was mentioned in Chapter 3 that training options can be divided in terms of the supplier: computer sellers, service bureaux and computer users. They tend to differ in the number, and variety, of assignments, promotion possibilities and access to related (highly substitutable) jobs vary among "internal markets".

Even within fairly similar firms of the same industry training practices differ considerably. Interviews revealed that decision-makers are very aware of the non-existence of accepted training procedures and standards of performance. The problem is a very basic one: the computer system is essentially versatile, the user must choose the desired configuration of an imperfectly understood system: a choice that is made after analyzing the type of information to be processed, and the constraints imposed by the internal market. Firms are by no means all alike, and the choice of an adequate or efficient design partly depends on indumbent specialists, since it is usually their job to estimate the relative opportunity costs of the alternatives available.

The characteristics of internal markets are important since they can influence the preference for determined types of manpower in terms of educational, and work, background, thereby constraining the actual choices of computer systems, and the characteristics of jobs and training.

The heuristic approach followed by employers in the specifications of the computer system, and the demand for manpower and training offered, is compounded by the fact that employees when first entering commercial computing often know very little about the task, and what frequently becomes important, they know little about their preferences for job content. The most striking example is the tendency to prefer either tasks that involve social intercourse as a major feature, say, systems analysis, or tasks that are essentially a "man-machine" interaction[1] (software programming for instance).

Employers and employees do usually acquire information about the state of the computer specialists market. Interviews showed that the two main sources of information were job offers published in La Vanguardia Española -- the largest Barcelona daily newspaper -- and confidential information on earnings, turnover, promotion, and selection practices, provided by colleagues.

The information exchanged among groups of people working in commercial computing strongly suggests that wages, and earnings, differ considerably among firms, although the disparities are narrower among installations with fairly similar characteristics. The spread of earnings for the same category of employment is partly explained by the heterogeneity of manpower classifications in commercial computing: the same occupational label often refers to different task mixes.

Data on earnings based on samples of firms that are used as a reference by the firms providing the data should be interpreted in much the same way. The economic rationale for this situation resides in the effect of continuous technical change upon the efficiency cost-effectiveness of developing standardized occupational classifications; to put it differently, the heterogeneity of labour inputs is not overcome because it would require the standardization of job descriptions, an inefficient policy when technical change is a dominant feature.

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1 This polar distinction is not always seen in practice, but computer specialists often approximate the problem in these terms. Another example is the difference between being the head of the computer department, a managerial job, and working on specialized fields such as systems analysis. Interviews showed that managerial tasks deal with single, non-programmed situations, whereas "typical" tasks in commercial computing work on regularities and in the specification of programmable -- logical -- processes. Many interviewees were convinced that few individuals feel at ease in both, usually either of them is preferred. Similarly as such preferences are rarely known at the outset, a trial and error process is frequently followed in the choice of specialization.

The analysis of manpower shortages is likely to produce ambiguous results, since the underlying heterogeneity of techniques and occupations in computing, and the multiple adjustment variables used by employers to adapt to changes in technology and in the computer specialists market, imply that earnings are now what the market equalizes and, therefore, changes in earnings do not measure the extent of the "shortage". (Of course, if this is the situation, it is not quite clear what is the analytical meaning of a manpower shortage).

The relativity of occupational labels and the importance of the actual tasks performed on the job — the main issues analyzed in this section — are important in the understanding of several issues on formal education.

5.6 Formal Training and Certification

This section will not discuss formal training in commercial computing in Catalonia since it would coincide with what is said in Chapter 4. Instead, the discussion will centre around the educational background of incumbent computer specialists and the attitudes towards the 1969 legislation on the validation of work experience.

Among highly specialized computer specialists in Catalonia two types of tertiary education predominate: (1) those with a business or economics degree (perito mercantil, profesor mercantil, intendente mercantil and economista);and (2) those with engineering degrees (perito industrial and ingeniero industrial). These trends have been influenced by demand considerations, such as the belief that business data should be analyzed by people with business background, and by supply considerations, as in the case of the "ingenieros industriales" during the late 1960's and early 1970's.

The demand for problem solving, and the novelty of commercial computing in the 1960's influenced the propensity to recruit people with tertiary education, partly due to the belief that there is a correlation between thinking ability and education. To the extent that the ability to understand the workings of physical equipment (electronic, electromechanic and magnetic) was demanded, engineers appeared to possess the most substitutable knowledge. Besides, in Spain there is a tendency to associate engineers with logical thinking and also with problem solving using mathematical tools.[1] Mathematicians and physicists can also be included in this group, though they represent a small part of the market.

Business and economics looked also highly appropriate for commercial computing because the information processed is business information and it is reasonable to assume that those who are familiar with this information, and the processes and trade-offs involved, have a comparative advantage when such procresses are to be mechanized.

From what has been said so far it might be inferred that in the long run educational backgrounds will tend to polarize. Business specialists moving towards the tasks that deal with business information, say, systems analysis and manpower with engineering degrees moving toward the "specialist-computer" interface, for instance, software programming.

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1 Civil engineers in Catalonia do seem to conceive their "profession" in a very broad sense; views are neither uniform nor constant over time. The sociological study of the profession indicates that this opinion partly reflects the existing flexibility in many jobs and that substitutability between educational backgrounds is particularly strong at the managerial level and in those areas where the decisive skills are problem solving of poorly specified assignments or decision-making under considerable uncertainty. Such an attitude seems to be consistent with the existence of graduates in engineering and on business side by side in commercial computing. This observation is incisively discussed in Marcos Alonso, <u>Los Ingenieros entre el Pasado y el Futuro</u>.

This may or may not become the outcome in the future, but so far, the trend among computer users is far from clear. The explanation of this heterogeneity has to be found in the characteristics of the "internal market" and the relative power of job incumbents that control the computer department.[1] The underlying theme is always the same: Computer systems are versatile, firms differ in their cost-structures and so do the cost estimates of decision-makers, thus leading to heterogeneous inputs.

The second issue to be dealt with in this section, refers to the disrepute of the validation of experience for the degrees created by the 1969 legislation. Access to these degrees was only open to those with a certain level of education and a minimum number of years of working experience in commercial computing -- both prerequisites related to the length of the course leading to the degree on computers. The candidates had to enter an examination set up by a committee of university professors.

Computer specialists reacted in different ways: some took the exams, some did not; many objected to them on matters of principle, or on the grounds that the exams consisted of assignments that could hardly produce a meaningful estimate of the capabilities of experienced specialists.

It is the later weakness that proved fatal to the validation policy. Employers and employees who went through the exams noticed that the concession of those qualifications was generally arbitrary from a market point of view: the examination results were not indicative of adequacy of the successful examinees to the computing tasks that were supposed to coincide with each degree defined by the 1969 legislation. Nor did the

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1 I must recall that the influence of job incumbents in resourse allocation choices under uncertainty is well documented by Pettigrew, <u>The Politics of Organizational Decision-Making</u>

certificates offer evidence of formal training, since the purpose of the exam was to validate experience in terms of educational qualifications. That such a policy failed is shown by the fact that employers do not ask for them. The reason has already been given: such "educational" certificates are not efficient as proxies for the productive value of the candidate: the signaling value of the certificate is nil.

In short, this section supports the conclusion that decision-makers in commercial computing are aware of the relevance of the content of formal education (certificates) as a proxy for problem solving, and that certificates fail to win market acceptance when they are based on unreliable assessments. Before concluding this chapter, I show that there are grounds for inferring that commercial computing in Catalonia is far from a representative sample of commercial computing in Spain

5.7 Regional differences

The analysis of the Catalan market cannot be followed by similar studies of other regional markets due to limitations in background information. However, taking the Catalan case as a reference, the evidence gathered in Bizkaia, Gipuzkoa, Madrid and Seville[1] confirms: (1) the interdependence between demand for output, supply of inputs and choice of technique (and training); and (2) regional differences.

It is shown in Chapter 4 that costs are often related to the extent of the market--size and characteristics of the demand for commercial computing . Such an explanation must be complemented by the characteristics of regional labour markets and of internal markets, in particular.

[17] Census data for December 31, 1970 indicates the following regional distribution of manpower in commercial computing: (Spain 100%), Catalonia and Balearic Islands, 23.5%; Andalusia and Canary Islands, 3.4%; Basque Country and Navarre 12.2%; and Madrid 46.7%. La Informática en Espana.

Thus, the Seville market exemplifies inefficiency to an extent only observed in central government installations; two "markets" that are not very competitive in terms of both labour and output. This, however, does not exclude the fact that extremely efficient instllations were found in Seville and in central government. The characteristics (competitiveness) of "internal markets" accounts for these deviations. Similar correspondence between the degree of efficiency in computer installations and "internal markets" was encountered elsewhere in Spain.

In other words, choice of technique and inputs cannot readily be related to the extent of the market for commercial computing. The demand for commercial computing is usually a derived demand: a decision variable in the set of activities undertaken by "internal markets".

Nonetheless, the extent of the market and labour mobility affect the actual cost of choosing a given technology. Sellers assistance ("back-up") is usually less efficient in Seville than in Madrid. As for labour, the Seville market is relatively small; enterprising specialists tend to migrate to the big markets (Madrid, Barcelona, etc.); and attracting experienced specialists from there is a challenging task.

The interregional mobility can be summarized in the following way: (1) Madrid attracts specialists from all over Spain; (2) large cities receive an inflow of qualified people from the region, or province; (3) movements in the opposite direction are rare; and (4) the Catalan and Basque markets do not normally consider the supply of specialists from other regions as part of the relevant supply.

Discussing manpower shortages after what has been said may seem inappropriate. However, it is done because among employers and employees in commercial computing it is often heard that "good" specialists are in short supply, both in slowly growing markets (Seville) and in rapidly growing ones (Gipuzkoa). The answer has already been given: firms neither share the same technique nor use policy variables in the same proportions, and in addition, wages are not uniform even within a regional market. It should also be noticed that firms are certainly aware of the implications of rapid changes in wage differentials among employees; this often being a major factor in the complaints on manpower shortages. For internal markets cannot always make major jumps in wage relativities and, at the same time, decision-makers know that in commercial computing, changes in relative scarcities can be counteracted by modifications in the design of the production process, and in the specification of outputs.

An implication of what has been discussed is the unreliability of interregional comparisons. Decision-makers, in commercial computing, are aware of the role of relative prices and the constraints imposed by "internal markets" and output specifications. That is why a comparison between, say, Seville and Madrid is likely to be misleading. For it is not a matter of size as defined by, for instance, income per capita or gross regional product; the qualitative aspects of inputs, their supply and demand, the characteristics of "internal markets" are decisive and they differ from region to region.

Seville is very traditional and so are the majority of "internal markets" there. Seniority and "loyalty" to the firm, and to the boss, are usually more important than competitiveness and motivation for self-improvement. Specialists whose approach to career development is based on personal achievement tend to migrate to the north (Basque Country, Catlonia and Madrid). Andalucia has an economic and social structure that differs profoundly from what is seen in the other areas studied in this research.

What Seville shows is, to a much lesser extent, seen in Madrid as a result of the practices of central government. Specialists interviewed in Madrid usually stated the view that the computer specialist market in Madrid was far less competitive than the Barcelona one. This was an impression that was not confined to computer specialists, but also to highly qualified manpower. Madrid does not have a market for job offers in the way Barcelona has through the newspaper La Vanguardia Española; personal connections play a much larger role in Madrid than in Barcelona.

The Basque Country, on the other hand, offers a combination of low intraregional, and even intra-provincial, mobility and a predominantly competitive approach to commercial computing. Therefore, it is not the size of the market for commercial computing that makes this industry competitive in the Basque Country. The importance of efficiency and achievement in most "internal markets" is a major factor in the competitive approach to computing. Basque computer specialists are conscious of the need for a process design (selection of input specifications) that minimizes costs for a given output specification.

The relevance of "internal markets" and their influence on the workings of computer installations was confirmed in almost all interviews. Choice of technique, manpower policies, and training are not the result of choosing the optimal combination of inputs in a perfectly competitive environment. Not all firms face the same range of choices of technique. Policies as to what, and how, information (technique and training) is to be bought vary from firm to firm. In commercial computing, firms cannot be assumed to face the same book of blue-prints because the current knowledge they possess and the prevailing practices, and policies, in their internal market pre-determine the range of choices of technique, and training in particular.

In short, regional studies are warranted, though the same cannot be said about inter-regional comparisons. Markets for inputs and output vary from region to region, and so do internal market practices — the policy, and input, mixes used by decision-makers.

5.8 Conclusions

The analysis of the Catalan computer market does not differ substantially from the discussion of the Spanish market, except for the specificity of some conclusions, such as the realization of the competitive character of the Catalan market. Regional differences are influenced by the characteristics of inputs as well as by internal markets.

The fundamental conclusions are that decision-makers view: (1) the computer system as a set of imperfectly understood interacting devices (human and physical) subject to an uncertain technological evolution; (2) that the specifications of technique, inputs and outputs are interdependent; and (3) that firms differ in the technique and price set they face.

Chapter 6

SUMMARY AND CONCLUSIONS

6.1 Training as a Constraint in Staffing a New Technology

This dissertation studies how firms staff a new and changing industry, in a rapidly developing economy. Staffing new technologies cannot be dealt with independently from choice of technique under uncertainty, since choice of technique is constrained by training. Additionally, the analysis of training in new skills turns out to be a particular case of information-acquisition under uncertainty.

The theoretical framework is based on the link between skills and training provided by the problem-solving nature of work. Training is considered as a constraint of choice of technique. An explanation of the emergence of formal training and training specialization is offered. Skill-acquisition is not considered as a black box: what is learnt, and how efficiently trainees learn is economically significant because of: (i) the economic value of the types of problems that trainees have learnt to solve; and (ii) the signaling value of problem-solving capabilities as reflected in the training performances and the content of training.

With the theoretical and policy issues in context I deal with training and staffing in Spanish commercial computing. This case study of new technology is analyzed with an emphasis on possible policy implications. Finally, I conclude with suggestions for further research on the concepts of skill and training as used by economists.

6.2 Training Problem-Solving and Choice of Technique

The analysis of training in new and highly sophisticated skills has to include technology as a decision variable, since training choices in a new technology are influenced by choices of technique. However, the relationship between training and technique is by no means a simple one. From an economic standpoint a technique does not consists of a set of unambiguously specified scalars. The conjectured exchange-value of a technical specification, which includes job designs and training policies, is influenced by the interactions among expectations on relative scarcities, choices under uncertainty, and costly information. And it is to these interdependencies, and their evolution, that I devote the following paragraphs.

A new technology consists of costly information about a production process (inputs and outputs specifications) that is subject to uncertainty. Training, on the other hand, can be considered as costly information acquired by employees. Defining training in terms of information, and more precisely as problem-solving significantly increases the analytical usefulness of the training concept. Training endows trainees with abilities to solve sets of problems encountered in production. Caeteris paribus, <u>the economic value of training depends on: (1) the similarity or dissimilarity between different solving abilities for production problems, that is, the level of generality of the training content; and (2) the relative scarcity of types of training</u>.

The popular notion that trained individuals are more productive than untrained ones can be explained in terms of problem-solving. Production consists of a set of tasks which are problems to be solved. They can be solved either by human capital in conjunction with physical capital, or by human capital alone. The first alternative relates to taks that can be partially or fully automated, that is, to tasks that can be unambiguously specified. Whenever a task or a group of tasks cannot be spelt out in a logically precise way, labour must be brought in for the simple reason that labour is the only input that can solve ill-defined problems.

This being the case, are all production problems alike? Or, is it possible to identify different sets of problems?. In other words, what explains the emergence of formal (off-the-job) training, and why does specialization in formal training take place?

Production problems are not all alike. Variables relevant to certain problems are not significant in others. For example, the understanding of physical properties of alloys is not relevant to woodworkers. In addition, production problems cannot all be solved following the same procedure. Thus, as shown in chapter 2, logical methods are adequate for problems with trade-offs that can be well specified and predicted, but problem-solving under uncertainty, say, entrepreneurial decision-making, is not solvable by pure logical thinking.

Technologies like academic disciplines share some things and differ in others, thereby making any calssification somewhat arbitrary as: (1) boundaries are not independent from the classification criteria chosen; (2) boundaries are often blurred and prone to change as new problems may belong to more than one of the existing areas of study or 'technologies'; (3) the typification of problems into academic disciplines and training syllabi is the result of the interplay of technological, political and economic forces; and (4) strictly speaking, it cannot be stated which is the most efficient classification of production-problems for training purposes: due to novelty what is deemed efficient today may not appear so tomorrow.

Since an efficient taxonomy of skills cannot be established, I concentrate on how specialization in problem-solving develops and how formal training emerges. I conjecture that a typology of new problems may be developed over time if the new problems recur often enough, as in such situations it may be efficient to produce a set of standardized solutions.

Given a new set of problems the emergence and evolution of formal training, either off-plant or in-plant-off-the-job, is going to be influenced by: (1) the demand for and supply of training for that set of problems; (2) political forces, say, pressure groups attempting to influence legislation on education degrees; (3) existing formal training specialties; and (4) the uncertain evolution of the rate and content of technical change.

This combination of influences results in job design, training, hiring and promotion standards being considered as interdependent policy variables, since in an interacting system where uncertainty is a major consideration, fixing or specifying unambiguously the above policy variables is bound to be inefficient. In other words, training is a variable that cannot be specified independently from the choice of a job design or technique.

These interdependencies are far from simple in new technologies since: (i) decision-makers are not choosing among unambiguously specified technological alternatives in new technologies; (ii) information is costly and inevitably incomplete as the problems resulting from novelty cannot be fully known a priori; (iii) individuals conjecture the exchange-values of technical configurations for an also conjectured state of the world; and (iv) decision as to what, and how, to learn about a new technology influence the actual understanding of technology, the conjectural exchange-values assigned to the set of techniques the decision maker becomes acquainted with, and thereby the eventual choice of technique.

In short, it can be concluded that in new technologies: (1) there are no books of blue-prints; (2) uncertainty, imperfect information and heterogeneity of inputs and outputs cannot be dealt with by means of the concept of the micro-production function; and (3) training and employment specifications are not independent from choice of technique. As I show in the following section this conclusion summarizes the inevitable ambiguity of the concept of manpower shortage in new technologies.

6.3 Training and Manpower Shortages in New Technologies

The belief in shortages of highly qualified specialists is commonplace in new technologies. In this section I analyse the conventional solutions to manpower shortages. According to neoclassical labour theory, manpower imbalances are overcome in the short run by price changes, by lowering hiring standards, or by both. In the long run, investment in training is the solution. In a rapidly growing industry well-qualified specialists are bound to be scarce and labour turnover high.

This is probably why a manpower shortage, as perceived by the employers interviewed in this research, has two drawbacks: (i) it produces a severe distortion in pay differentials; and (ii) it causes inefficiencies in production. Government intervention in the form of manpower planning is often considered as more effective than market forces in overcoming manpower shortages. But, in the light of this research, is manpower planning preferable to competition? The ensuing discussion is presented in terms of the manpower requirements approach used in the Mediterranean Regional Project[1] as this is a 'strong' version of manpower planning due to the fixed coefficient assumption.

The implicit assumption behind educational planning is the existence of rigidities in the labour market for educated people that cause imbalances between the demand for and the supply of educated people.[2] Whether to satisfy the demand for educated people or the demand for education by private individuals is a dividing issue among specialists.[3]

In so far as the issue is a manpower shortage, I must deal with both the demand for trained people and the demand for training. Existing methods usually concentrate on either the educational system, the input-output method for instance[4], or the labour market, as in the case of the manpower requirements approach used in Spain in the framework of the OECD Mediterranean Regional Project.

I begin by studying the labour market in order to find out the size and composition of the alleged manpower shortage. I discuss a'strong' version of manpower planning because the case for competition becomes plausible, when factor substitusion is allowed for the model, to say the least; since flexibility amounts to saying that firms can differ, heterogeneity is possible and consequently disaggregated decision-making is called for rather than centralized planning.

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1 The Mediterranean Regional Project. Country Reports Spain (OECD Genève: 1965).

2 Basir Ahamad and Mark Blaug, eds., The Practice of Manpower Forecasting (Amsterdam: Elsevier Scientific Co. 1973)

3 R.P.G.Layard, "Economic Theories of Educational Planning", Essays in Honour of Lord Robbins M.K.Peston and B.A.Corry eds., (London: Weidenfeld and Nicolson, 1972), p.118.

4 Samuel Bowles, Planning Educational Systems for Economic Growth (Cambridge: Harvard University Press, 1969). p.84.

The manpower requirements approach assumes that factor substitution is not possible, and that training can be designed to meet employers demand. In a competitive market this implies an unambiguous correspondence between training content and job design; otherwise the shortage would not exist, as job openings would have been filled by individuals possessing other skills. Such an assumption relies on the possibility of producing an unambiguous specification of the technology, task contents, and ultimately job designs. Approximations would not do, as the market already produces specialists capable of solving highly sophisticated problems; and, after all, that would imply factor substitution which would contradict the assumption of fixed proportions.

Empirical evidence on commercial computing does not support the assumptions behind the manpower requirements approach. New techniques are imperfectly understood, they are not fully specified and they undergo continuous changes due to market forces. The manpower requirements approach is inadequate for new technologies mainly because inputs and outputs are heterogeneous, multi-dimensional, their specifications are variables not parameters, and factor substitution is possible. The difficulties go beyond the accuracy of forecasts and the specification of tasks. Job designs and the tasks involved are not specified once and for all, they interact with market forces: they are policy variables. As a result, aggregate occupations and outputs are heterogeneous categories that cannot be used for forecasting. They are the outcomes of factor substitution undertaken by decision-makers who differ in the inputs they use, the perception and response to uncertain change, and attitudes and expenditure on information.

Therefore, the criticism against manpower planning in new technologies is ultimately based upon the empirical fact that job design, training, hiring, promotion and output design are policy variables. In other words, the criticism is against the reliability of technological forecasting.[1]

If manpower planning cannot produce an adequate supply of highly qualified specialists in a new and rapidly growing technology, should the emphasis be put on market forces, that is, on stimulating competition? In a new technology, market signals are ambiguous and costly to interpret and therefore decision-making is best left to employers and employees. They alone can conjecture the relative attractiveness of options known to them.

The realization of the analytical ambiugity of both, manpower shortages and then belief that they result in sub-optimality in production is a by-product of this discussion. These implications follow from the built-in flexibility of new technologies. Strictly speaking, there is no such thing as a technically optimal specification in a new technology, since the level of specification is influenced by: (a) financial resources allocated to specifying a technology; and (b) the conjectural nature of choice of technique under uncertainty.

Yet, if there is no such thing as technological optimality, if input and output specifications are decision variables, if manpower shortages are ambiguous scalar measures, if the rate and direction of technological change are uncertain, and if decision-makers differ in their perceptions of uncertainty and risk, how much reliance can be put on manpower

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1 I do not enter into the debate as to how reliable technological forecasting can become since the issues are many, complex, and extend well beyond the scope of this thesis as can be found in Erich Jantsch, Technological Forecasting in Perspective (Paris; OECD, 1967). This study puts forward the view that technological forecasting is becoming increasingly complex, though gradually more accurate.

planners? Are they going to overcome the prevailing uncertainty and heterogeneity? This is logically impossible. Predicting the future using information which is essentially ambiguous is unlikely to "improve" the workings of the market. For, it is precisely what a market for a new technology lacks, what is also lacking in manpower planning, that is, insight into the future. Market information in new technologies is so unreliable because current information is believed to be of little help in knowing the future. But, is it not current information plus conjectures which the planners use as raw material to produce the "information" that the market cannot supply?

In short, the continuous evolution of new technologies and the heterogeneous responses from decision-makers should not be interfered with by manpower planning, as there is no way to define either the extent of the "shortage" or its economic meaning in an unambiguous manner.

But, once the market produces reasonably unambiguous information and formal training emerges, what happens to educational planning? The improvement of market information usually coincides with a process of input standardization and in so far as this amounts to fixing some production coefficients, manpower planning for highly qualified people in new technologies seems to gain strength. However, this inference would only be sound if fixity were to affect labour. But in Chapter 3 I show that fixed coefficients develop in physical capital as manpower is relatively inefficient in performing routine tasks, that is, tasks peffformed using abilities in fixed proportions. The consequences of the development of formal training on manpower planning are further discussed in conjunction with the signaling value of education since both refer to the connection between what is learnt off-the-job and what is done on-the-job.

6.4 The Signaling Value of Training

In the foregoing section I show that manpower planning in new technologies is not warranted because the demand for manpower cannot be summarized in unambiguous scalar measures. Decision-makers act differently upon physical-inputs specifications, training, promotion, output configurations, and the level of production in order to take advantage of the flexibility and heterogeneity of technology and labour.

This interactive behaviour is not incompatible with the emergence and specialization of formal training. Technology does not dictate how formalization will take place: politics, demand and supply for new problem solving, the existing division of formalized knowledge, and the characteristics of suppliers of other types of training are also elemental in shaping: (1) typologies of new problems; (2) the development of new formal-training specialities and certificates; and (3) the institutionalization of training.

The case for educational planning is further weakened when the ambiguity of scalar measurements of manpower shortages is compounded by the non-existence of perfect match between formal training and employment, as this precludes the translation of the demand for educated manpower into an unambiguous demand for manpower defined by their formal training.

How do employers cope with the loose equivalence between formal training or certificates and occupations? As argued in Chapters 4 and 5, employers in commercial computing when they consider hiring an individual they look into: (1) the content of formal training; and (2) how proficient the candidate was in learning. The training syllabi provides a rough guide to the types of problems the prospective employee has learnt to solve and suggests how familiar he is already with the types of production problems to be encountered in the job. Proficiency in learning is also relevant as all jobs involve a certain amount of learning to solve problems specific to the firm. Thus, employers can gain an insight into: (a) how costly this learning may be; and (b) the costs of possible job transfers and promotions in the future. These costs are very relevant in new and rapidly evolving technologies, as the obsolescence of know-how leads to a periodic involvement in learning new techniques, staffing newly created jobs, etc., thus making the potential for learning a relevant economic variable in the selection of employees in commercial computing.

To put it differently, formal training has a signaling value for employers due to the problem-solving nature of education and work and the differences between training content and production problems.

Polar versions of screening and human capital theories seem to dispute on a non-specified box, that is, both views take training as a black-box which is either empty or full of productive knowledge. The polarity, the opposition between training as selection or substantive learning, can be disposed of by the combined use of: (1) training as problem-solving; and (2) the empirical fact that trainees differ in their learning performances. For this conjectured nature of training in a world described by (2) will necessarily produce the elements for selection of the best according a criteria: the relative ability in solving problems. But, is this all? Indeed, it is not.

It can be stated that training inevitably involves selection in so far as some learn better than others. But to state that training is merely selection is a valid proposition, only if it is shown that the selection criteria exclude problem-solving. However, if training offers no substantive knowledge or problem solving, how are people selected? How can trainers find out the psychological traits of character that are "required" for a certification of the possession of the right blend of personality to take up jobs that demand certain probem-solving abilities?

Thus, according to my specification of training: (a) the screening hypothesis is at best incomplete, and certainly misleading; (b) training is more than a device for "selection", it deals with problem-solving which is an economically relevant feature of production; and (c) whether those engaged in problem-solving learn, or merely exercise innate abilities, cannot be answered conclusively, in so far as there is no way to define learning independently from innate abilities; ultimately there is a taxonomical issue, and therefore it is a matter of conjecture what constitutes acquired skills, innate abilities, and how they are identified in individuals.

There is a relevant extension to the above discussion. Scarcity is what gives an exchange-value to the problem-solving nature of training. What the psychological nature of problem-solving is, or how it is acquired, are related but altogheter different issues.

They refer to: (i) the psychological explanation of the origin and nature of knowledge and abilities; and (ii) the relative cost of different ways of learning to solve a given set of problems. The latter point cannot be dealt with in general terms, it can only be discussed case by case and in terms of the known, or existing, training methods. Furthermore, I question the generality of the relationships between the economic value of education and physical productivity and the use of information in the production process. On the one hand the above specifications cannot encompass decision-making under uncertainty, as the very decision is neither physically contributing to output nor does it take information as the major input, if anything un-knowledge or uncertainty is the distinctive input. On the other hand, my definition of training as problem solving is compatible with all these types of activities and problems, and still gives due credit to the scarcity aspect of training.

Thus, it can be concluded that: (1) the emergence of formal training does not make manpower planning more reliable, since it compounds the ambiguous character of manpower shortages; (2) training has a signaling value; and (3) screening is an inevitable part of training as problem-solving when account is taken of the empirically observed differences in training performances among individuals, the loose connection between jobs and training, and the problem-solving nature of work;

So far I have shown mostly drawbacks and ambiguities on the concepts of manpower shortage and educational planning. In the next two sections, I outline results that are more constructive for policy purposes.

6.5 Training and Manpower Shortages in Spanish Commercial Computing

Electronic data processing is a technology that has been growing at a very high rate since it was applied to computing commercial information in the 1950's. In addition, the technology has undergone a continuous process of change that does not show signs of stabilizing yet. Concrete references to technical aspects are omitted here, as they are not essential to the exposition.

Commercial computing allows for a great deal of flexibility in the specification of inputs and outputs, thereby making training options dependent on choice of technique. Decision-makers have imperfect knowledge, and are aware of the pervasive role of uncertainty. Or to use a different label, the concept of micro-production function is not valid in this context because: (1) a book of blue-prints does not exist in commercial computing; (2) uncertainty and costly information are major constraints; and (3) inputs and outputs are heterogeneously specified variables. Decision-makers adjust to technical change and factor of output prices via production-process redesign (which can include job redesign, training redesign and output redesign) and changes in hiring and promotion policies.

As computing installations vary in job designs, profiles of job incumbents, and hiring and promotion policies, it is not possible to specify a "manpower shortage" in a meaningful way. For even if there is conclusive evidence that the increasing demand for highly qualified specialists has not been met by a similar expansion in the supply of "trained" or experienced specialists, there is no basis for the specification of the profile of the "adequately" qualified specialists for the "optimally" designed jobs. Standard designs simply do not exist, except probably for skills that have gradually become formalized, like, for instance, computer programming. Though, to many specialists computer programming (as defined in Chapter 3) is no longer a "highly specialized" set of skills.

Empirical evidence shows that employers and employees are influenced by the differences in problem-solving among jobs, and the related transfer costs from one set of tasks to another. The transfer cost can be approximated by comparing the contents of the problem-solving involved with relative scarcities of the training contents involved. That is, decision-makers in commercial computing consider that training and work experience has a signaling value in so far as it can be taken as a proxy for employees' capabilities.

Another substantive finding is the sequential approach to training investments in commercial computing. <u>Trainees, in almost all cases, find that their views about their capabilities and tastes on training and work in commercial computing change as they become engaged in actual training and work</u>. In other words, the evaluation of the economic worth of a career in commercial computing undergoes qualitative changes as the newcomer becomes acquainted with actual computing tasks. The ignorance, and uncertainty, is such that traits of character, like preference for a challenging unknown tend to play a major role in job and training choices in commercial computing.

While the degree of ignorance as to what computing consists of decreases among new entrants as the industry becomes more established; newcomers still go through changes in tastes and revise self-assessments on their capabilities. The evidence I collected strongly suggests a very imperfect knowledge of work preferences and capabilities among prospective computer trainees, particularly among teenagers and people in their early twenties. The importance of this phenomenon in Spain, is presumably strengthened by; (1) the non-existence of widely accepted training certificates restricting the ease of entry into commercial computing; and (2) the non-existence of an "institutionalized profile" of what commercial computing consists of.

Finally, I found that the characteristics of "internal markets" are as influential as market forces in the choice of technique, staffing and training in new installations. Market forces are dealt with separately in the next section, since their significance is likely to extend beyond commercial computing.

6.6 Policy Conclusions

Whether Spanish markets for highly qualified manpower work efficiently cannot be ascertained with the available evidence. Rigorously speaking, the question is an irrelevant one, since, as shown in Section 2.2, discussing efficiency is beside the point when uncertainty and imperfect information prevail.

As for shortages of highly qualified specialists little else can be added to what has already been said. I have reasoned why the concept is analytically ambiguous, unsound and empirically useless. To reiterate, the ongoing adjustment processes to changes in technology and relative scarcities alter the meaning and measurements of labour imbalances, as the ease of substitution is also affected by changes outside the boundaries of the labour market. That is, the degree of factor substitution is not a technologically given parameter but a decision variable which is specified according to perceived opportunity costs.

Moreover, I have shown in Chapters 4 and 5 that: (1) Spain has undergone profound changes in the economy and the labour market since the late 1950's; (2) regional differences are very important ; and (3) the available information cannot always be unambiguously interpreted -- statistical data, in particular, being of low quality.

The inadequacy of planning the supply of highly qualified specialists for new technologies, or those new in Spain, does not imply that the Spanish economy is severely handicapped and that economic growth is adversely affected. The alleged disadvantages resulting from the inappropriateness of manpower planning as a policy to overcome a price-rising adjustment to a continuously expanding demand for given skills rests on a misconception. This follows from a simplistic application of neo-classical price theory to an environment that is highly sensitive to persistent widening wage differentials for certain groups of employees, due to a rapid, and sustained, growth of the demand for a given type of skill.

In a neo-classical framework, market adjustments take place in a world of certainty, full information and refer to homogeneous (unambiguously defined) inputs and outputs that are produced following a technology common to all producers. In the long run, homogeneity is relaxed and decision-makers can add changes in technique, design of inputs and outputs, hiring, and promotion policies to the price-quantity adjustments available in the short run.

However, in markets for new technologies, decision-makers do not just "relax" the homogeneity assumption. They assume that uncertainty, not risk, and costly information are also crucial constraints and thereby: (1) there is no such thing as "the optimal" combination of resources; (2) the decision-making process must be piece-meal and tentative, and (3) the specification of inputs and outputs is not a technical datum but the result of the interactions among technological "potential", research outlays, and the constraints imposed by the structure and functioning of "internal markets".

That is why the growth in Spanish commercial computing has ultimately depended not merely on factor endowments, but also on relative costs and the technological flexibility of commercial computing. And, surely, this is a major finding since it disposes of the belief that developing countries are decisively constrained by the non-availability of highly qualified computer specialists in their attempts to enter commercial computing. A country does not necessarily require specialists who can address themselves to new problems. For, it must be recalled that commercial computing is versatile and specifications can be adapted to suit relative scarcities and training on the job. This conclusion, naturally enough, does not pretend to minimize the difficulties in adopting commercial computing, it merely clarifies one of the issues involved.

This conclusion clearly differs from the Mediterranean Regional Project recommendations for Spain and Horowitz' Manpower and Education in Franco Spain. According to the former:

"Spain should embark upon a major programme of educational development in line with its plans for economic growth which provide for the doubling of the gross national product between 1961 and 1975...

"Such a rate of growth naturally implies major changes in the qualification structure of the labour force. If industry, agriculture and transport are to be modernised and put on a competitive footing with those of other countries, they must not only adopt new techniques, but above all find the qualified manpower to operate these techniques and put them to the best possible use" (the underlining is my own)".[1]

Is it not surprising to find the inconsistency between this statement of the problem and policies to adopt, and the choice of fixed input coefficients based on the proportions prevailing on currently used technologies and project them beyond a decade? To argue that Spain in the early 1960's was about to adopt technologies already well established in other countries does not solve the inconsistency. I have shown that technique, staffing, and training are not standard packages in new technologies, that is, in technologies that are new to those who use them. Choices still have to be made under uncertainty, imperfect information is still costly, and the country's relative scarcities together with the political pressures from existing economic groups influence decision-makers to an extent that cannot be reliably predicted; each decision-maker must make his own conjectures about the future state of economic affairs and the future of the industry he belongs to. Furthermore, there is no reason to assume that these sets of interacting forces coincide with those of any other country at any point in time. If anything, the existing evidence, and economic analysis, suggest the contrary.

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[1] O.E.C.D. op.cit. pp.14-15

The relevance of my criticism is by no means diluted by the fact that my thesis is about a very specific set of skills and the Mediterranean Regional Project was about the entire Spanish labour market. For, if the analysis of a small set of skills is beset with uncertainties and ambiguities, aggregating a larger set of skills that have these traits is bound to increase the heterogeneity and ambiguity of the resulting aggregated scalars for the more broadly defined occupational and educational groups.

If in the early 1960's the Mediterranean Regional Project was inconsistent, in the early 1970's Horowitz did not show signs of having realized the impossibility of matching manpower "needs" and educational output on the basis of (1) an estimation of the "needs" of an economy, conjectured or purposely planned, to grow at a certain rate; and (2) subsequently designing the "appropriate" training syllabi.[1] It is not just that Horowitz never bothers to state the assumptions underlying his planning strategy, or the ways to overcome the unreliability of information on the Spanish labour market, or what he means by manpower shortages. For if in Chapters 3 and 4 he convincingly demonstrates that the Spanish labour market was very distorted by government interventionism and labour legislation, what is one to make of his remarks about manpower shortages and the alleged market failure in overcoming them and the need for manpower planning.[2]

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1 As long ago as 1964 this issue was settled by H.S.Parnes, "Relation of Occupation to Educational Qualification", <u>Planning Education for Economic and Social Development</u>. H.S. Parnes ed., (Paris: OECD, 1964)

2 Horowitz, op. cit. pp. 131 and 132.

Furthermore, it is indeed unfortunate that Horowitz' book does not once address itself to the problem of how training content and occupations are to be satisfactorily matched to one another in qualitative and quantitative terms. Nor does he bring to the surface the implications of the underlying factor substitution that made possible the very rapid economic growth of the Spanish economy during the 1960's. In my view, the evidence and analysis contained in Horowitz' book does not necessarily support the view that "proper" manpower planning would do better than market forces. On what the books show, a case for a more competitive market could also have been made. Thus, while I admit that due to Horowitz lack of analytical rigour, either main conclusion seems feasible a priori, I go a step further and state that Horowitz makes two points that I fully subscribe to in my thesis: (1) very little is known about the workings of the Spanish labour market; and (2) labour statistics are very unreliable.

Though I must also add that these two conclusions are more constructively presented in Jané Solá's El Problema de los Salaries en España. Thus, while Horowitz discussion of manpower planning in Spain does not improve the understanding of what happens in the Spanish labour market and the practical usefulness of manpower planning as a policy instrument, those concerned with the interactions between the educational sector and the labour market can infer from Jané Solá's book that the link between education and occupations cannot be specified on the basis of existing information on the labour market. This state of affairs still prevails according to the contributions cited in Chapters 4 and 5.

As a final, but important consideration, I must stress the very limited understanding of how Spanish regional markets for highly qualified people work. Nonetheless, research done on the Catalan labour market confirms: (1) that factor endowments, as much as relative prices and technological flexibility, were and remain elemental in the growth of Catalan commercial computing; and (2) the elusiveness of the concept of manpower shortage as employers use job and output design, hiring, training, and promotion as policy variables when confronted with economic changes relevant to their activities. Evidence gathered for other regions does coincide with that on the Catalan market.

6.7 Further Research on the Concept of Skills

I cannot conclude this thesis without putting the major findings of this thesis into perspective. On the credit side of the balance sheet I can single out the analytical efficiency of training defined: (1) as a constraint in choice of technique; and (2) as problem-solving. This specification has allowed me to deal with the emergence of formal training, the specialization in training, the signaling value of training, manpower shortages, and more generally the connections between training and working activities.

The economics of training can no longer be confined to general and specific training defined on the basis of inter-firm mobility. Nor can economists feel at ease with ad hoc dichotomies like manual and non-manual skills. And, certainly, I do not feel comfortable with the poorly specified concept of "highly qualified" manpower. For in the case of Spanish commercial computing the definition could not be based upon educational qualifications. In fact, the content of these tasks, together with the acute scarcity of specialists capable of solving them, seems to offer a working approximation to the concept of highly qualified manpower; though, I must add that these dimensions are subject to continuous and profound changes. In short, further research is needed on: (1) the content, mobility, and scarcity of types of problem-solving or skills; (2) the relationship between skill-acquisition and innate abilities; and (3) psychological attitudes to risk and uncertainty.

I conjecture that economists might advance in the understanding of some of these issues if the analysis of economic behaviour that assumes the application of reason to circumstances was extended into the inquiry of (1) how does he know what those circumstances are;[1] and (2) how does he learn under uncertainty and costly information? Thus, problem-solving, that is, life consists of non-repetitive learning which amounts to trial-and-error processes or it is a repetitive task, a kind of "learning-by-doing"?[2] In either case the screening hypothesis does badly; strictly speaking, the screening hypothesis in its more extreme version has to assume that knowledge is not acquired but innate. In any case, it is more efficient to talk in terms of the signaling role of training, since what the training institution does is to select manpower on the basis of their relative performances in solving problems, even when these partly consist of behaving according to certain specifications, as in the case of some boarding schools.

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1 Shackle, op.cit. Preface

2 Popper, Unended Quest, pp. 44-45.

On the policy side, I must state that despite the ambiguity of measured manpower shortages and the difficulties inherent in manpower planning, I do not support the view that the government should not have a policy on commercial computing and on manpower in computing in particular. A government policy on this field is warranted by: (1) the fact that one supplier, IBM, controls over sixty per cent of the Spanish market; (2) central government is a large demander of computers and a government procurement policy, as the one currently in force, may help in reducing the oligopolistic character of the computer market; (3) computers affect the exchange-value of property rights on many assets, human and physical, and this results in pressure groups attempting to influence legislation; and (4) a new economic good cannot exist without a minimal legal framework, and current legislation does not always encompass all the legal issues that are raised by a new technology, say, the effect of computers on privacy.

In short, from this research it cannot be concluded that a government policy will improve the workings of the market necessarily. However, the analysis shows that: (i) a government policy cannot be avoided, even if only by default; and (ii) because of uncertainty and imperfect information government policies in commercial computing and on the market for computer specialists are inevitably tentative.

	Km^2	Population (1970 Census)	Population Density per Km^2	Labour Force Sectoral Employment (1974)			Migration 1941-70 per 1,000 inhabitants
				Primary	Secondary	Tertiary	
SPAIN	504,750	34,032,801	67	23.0	37.1	39.9	
Andalucia	87,268	5,971,277	68				
Seville	14,001	1,327,190	98	19.7	32.3	47.6	(-) 120
Castilla la Nueva	72,363	5,164,026	71				
Madrid	7,995	3,792,561	501	2.5	38.5	59.4	(+) 838
Catalonia	31,930	5,122,567	160	10.7 [1971]	51.3 [1971]	38.0 [1971]	
Barcelona	7,733	3,929,194	540	3.5	57.3	39.1	(+) 374
Vascongadas & Navarra	17,682	2,343,503	133				
Gipuzkoa	1,997	631,003	327	11.2	57.0	31.5	(+) 374
Vizkaia	2,217	1,043,310	494	5.7	53.2	41.1	(+) 517

Table 4.1
Basic Statistics

Source: Anuario del Instituto Nacional de Estadistica, 1975.

Table 4.2

Computers installed in Spain

1962	21
1965	129
1970	748
1974	1,651
1975	1,998

Data refers to January 1st of year cited

Source: Doblón, November 1975, p.10

Table 4.3

Sectoral Growth in Computers

Source: La Informática en España

Sectores	1962	1963	1964	1965	1966	1967	1968	1969	1970
(Fabril) Manufacturing	14.5	13.5	22.5	29.5	32.9	37.1	38.8	41.9	39.6
(Bancario) Banking	23.7	21.6	25.0	22.4	25.4	29.4	30.5	28.8	30.4
(Construcción Energia y Servicios) Construction, Energy and Services	28.6	32.4	25.0	18.6	15.1	10.8	9.3	8.5	9.3
(Administración Central) Central Government	9.5	5.4	6.3	9.3	8.1	7.4	6.6	5.2	5.6
(Administración Local) Local Governments		2.7	1.2	1.5	1.1	2.4	1.7	1.8	2
(Enseñanza e Investigación) Education and Research	23.7	16.2	11.2	10.1	9.3	5.5	5.8	5.2	4
(Servicios Informáticos) Computer Service Firms		8.2	8.8	8.6	8.1	7.4	7.3	8.5	9.1

Table 4.4

Spanish Minimum Wage Scales, 1967

Occupational Group	Grade Level	Minimum Wages			
		Monthly Rate		Daily Rate	
		Pesetas	Dollars[2]	Pesetas	Dollars[2]
Professionals (Titulados)	grade 1	5,670	81.00	189	2.70
	grade 2	4,770	68.00	159	2.27
Managers (Jefes)	grade 3	3,960	57.00	132	1.88
(Administrativos Foremen y capataces)	grade 4	3,420	49.00	114	1.63
	grade 5	3,150	45.00	105	1.50
(Subalternos Assistant Foremen y auxiliares)	grade 6	2,610	37.00	87	1.24
	grade 7	2,520	36.00	84	1.20
Skilled (Oficiales)	grade 8			96	1.37
Semi-Skilled (Especialistas)	grade 9			90	1.28
Unskilled*(Peones)	grade 10			84	1.20
Apprentices, 3rd & 4th year (Aprendices)	grade 11			56	0.80
Apprentices, 1st & 2nd year (Aprendices)	grade 12			35	0.50

1. The minimum wage for the unskilled worker is the one normally quoted as the minimum wage.

2. Dollar figures were calculated by converting the pesetas at the official exchange rate of 70 pesetas to the dollar.

Source: Sociedad de Investigactiones Económicas, Modelo Econométrico de Política Laboral (1954-1971). Tomo 1, 1967, p.195.

[M.A.Horowitz, Manpower and Education in Franco Spain, Hamden, Connecticut, Anchor Books, 1974, p.29.]

Table 4.5

Labour Force. Sectoral Employment

	1950	1960	1974
Primary	48.9	39.8	23.0
Secondary	24.5	28.1	37.1
Tertiary	25.0	27.5	39.9
Unspecified	1.6	4.6	

Source: Data for 1950 and 1960 comes from the Population Census. 1974 data comes from the <u>Encuesta de Poblacion Activa</u>

Table 5.1

Catalonia and Spain

	Catalonia	Spain	% Catalonia Spain	% Barcelona Spain
Population (1970)	5,122,567	33,823,918	15.26	3,929,194
Income per capita (1971) pts	93,657	70,761		
Employment (1970)(%)	100	100	16.68	12.55
Primary	10.90	28.4		
Secondary	49.82	35.4		
Tertiary	39.12	36.2		
Gross Value Added (1971)%		100	20.09	15.85

Sources: N.Serra et al., "Sobre l'Estructura Industrial Catalana", <u>Banca Catalana</u> 31, (December 1973); "Catalunya en Xifres", ed. Banca Cataluna.

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