

FISSION RISK OR INERTIA?

TOWARDS AN EVOLUTIONARY-ECOLOGICAL MODEL OF HUMAN CAPITAL DECISIONS[♦]

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Abstract

The evolutionary-ecological model presented here introduces a new concept, ‘fission’, in order to highlight the possibility of economically rational outcomes manifesting inert demand for human capital. The apparent paradox between the availability of skilled labour and an unresponsiveness of employers to its availability is shown to be the consequence of employer risk avoidance in the presence of ‘fission’, the dis-mantling or splitting of the employer’s company that may occur if it accumulates a critical mass of skilled labour who are capable of ‘spinning off’ to create a separate and potentially competing company. ‘Fission’ is likely to undermine an existing unit’s expected fitness and thus explain why employers are reluctant to hire top educated and skilled individuals. It is assumed here that when an additional top worker enters the firm, the risk of fission increases. Moreover, there is a real possibility that the nucleus of the incumbent firm ends up with no elements, that is, all the top workers will leave the firm (radical fission) instead of the firm diminishing but continuing with a positive number (partial fission). The “fission argument” implicitly assumes that there is a ‘threshold’ range of top skilled or top educated workers needed to run a plant. To the left and to the right of this range, the establishment’s fitness decreases. Statistical evidence, using a *logit* specification, based on data of the Portuguese textiles, provides estimates that seem to corroborate the fission hypothesis.

Keywords: Fission, Ecological-population theory; Evolutionary theory; Portugal; Textiles

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Introduction

The starting point of this research has been a critical examination of the mainstream economics concerning the demand side of human capital. According to the existing theoretical and empirical human capital literature, it is difficult to conceive that, in large swathes of seemingly still successful industrial capitalism, there are distinctly low limits on the demands placed on the education and training system by employers, unless one resorts to the belief that these employers must be ill-informed or irrational. This paper explores an alternative explanation, which combines heterodox economics contributions from organisational ecology (Hannan and Freeman, 1984, 1989) and the evolutionary economics (Nelson and Winter, 1982).

A new concept, ‘fission’, is introduced to highlight the economic rationality of choosing a low skills employment path. The foundation assumption for ‘fission’ is that organisational fitness is related not only to the actual productivity contribution of a highly skilled or highly educated person to the plant, but also to the probability that this same person will leave the plant to create or join a new (rival) unit. This departure of one or more individuals is referred to ‘fission’ and is likely to undermine an existing unit’s expected fitness and thus explain why employers are reluctant to hire this type of individual.

This paper is structured as follows: Section 1 presents three main theoretical approaches (human capital theory, ecological-population theory and evolutionary theory) relating them with the issue of inertia in the demand side of human capital. The following section (Section 2) exposes theoretically the fission model and Section 3 provides its estimation. Finally, Section 4 concludes the paper presenting the main findings of the research.

1. Inertia in human capital demand. Alternative theoretical approaches

1.1. Human capital approach

The works of Theodore Schultz (1961a, b) and Gary Becker (1962, 1964), which constitute the foundations of human capital theory, provided for the first time a comparative insight into the incentives for the accumulation of capabilities. Other (previous) authors have written about capital, and some of these (*e.g.*, Smith, Say and Senior) recognised that the productive powers of individuals could be augmented by the accumulation of skills or capabilities (much

like improving a physical capital good). However, these earlier writers did not embed their observations in a rational choice framework in which individuals were assumed to exercise control over their own accumulation of capabilities, a centrepiece of Schultz and Becker's works.¹

Much of the recent literature on human capital has focussed on the issues of the contribution of tertiary education to lifetime earnings and the related issue of mobilising the resources (societal or family) to continue education beyond the secondary level. The fact that tertiary education is not universal in any country has suggested to some that part of its finance must come from the individual's benefiting from it. At the same time, however, it is recognised that improvements in the average level of education and training a society may provide it with a higher level of social capability for dealing with the challenges of global competition and meeting other social needs (Abramovitz, 1986; Prais, 1995). Thus, a case remains for public finance of post secondary education, which may involve subsidising tertiary education and/or providing additional training for employed individuals and the level of such subsidy in any country may be governed by political processes and perceived opportunities. In this connection, it is important to recall the distinction between general and specific human capital as introduced by Schultz and Becker. Because general human capital improves the productivity of individuals, but is applicable in any employment, there are inadequate incentives for employers to invest in education or training that augments the individuals' general human capital. While doing so will increase the individual's productivity, the company will need to raise the individual's wages to retain them and hence there may be little or no net gain from such investments. By contrast specific human capital is only relevant to a current employer, and there is apparently little need for public subsidy for such investment as a share of it can be captured by the employer (who may raise the wage by less than the increase in the employee's marginal revenue product without increasing the probability of their leaving). Between these two 'ideal types' of human capital there are a range of possibilities for the joint creation of specific and human capital but the incentives can be analysed in the same way as in the case of the ideal types with proportions of employer and employee (or public) funding determined by the extent to which the accumulated human capital is general or specific.

The present study adopts a simple model of the accumulation of general human capital, ignoring the issues of specific human capital. In particular, two groups of workers, the 'top

¹ See Kiker (1966, 1968) for a detailed overview of the main contributors to the notion of human capital.

educated' and the 'top skilled' (i.e., those with the highest measured levels of human capital), were singled out for analysis as they turned out to be the main 'actors' of the fission hypothesis. 'Top educated' included workers with tertiary (university or polytechnic) education, whereas 'Top skilled' were workers classified (on the basis of the nature or complexity of their job tasks within the firm) as top or medium professionals. The differences between these individuals largely stems from how their general human capital was accumulated. In the case of those with tertiary education, it is the educational process that is assumed to produce higher levels of the human capital while the 'top skilled' workers are assumed to accumulate general human capital 'on the job' and through participation in publicly-funded training programmes. The nature of the industry, textiles, is important because, as a medium technology industry using widely standardised equipment, 'on the job' experience means that much of the human capital accumulation is general.

The existing theoretical and empirical literature relating to the human capital theory approach (e.g., Becker, 1962, Bartel and Sicherman, 1995, Kremer and Thompson, 1998) involves resorting to the belief that employers must be ill-informed or irrational to explain why there remain distinctly low limits on the demands they place on the education and training system. None of the authors following this theoretical approach have focused attention upon the determinants of demands for human skills and how those demands change (Ashton and Green, 1996). As the 'demand' side in rate of returns studies is already incorporated recursively in the formulation of the incentives for accumulation given the existence of labour market equilibrium, by studying supply one is studying demand as well. If there were an insufficiency of demand for higher levels of human capital, the incentives for its accumulation would be lower and the supply would automatically adjust to the demand. In this vein, most theory and research within human capital issues treat firms as rational, flexible, and rapid adapters to changing environmental circumstances.

When considering the application of human capital, studies in the human capital theory tradition implicitly assume that survival is not problematic. In fact, most of the existing empirical studies, both those that use database analysis (e.g., Bartel and Lichtenberg, 1987; Bartel, 1989, 1991; Michie and Sheehan, 1998) or case studies (e.g., Blanchflower and Burgess, 1996; Mason and Wagner, 1998) neglect the issue of organisational survival, focusing their analysis on firms that are in business at the time of survey or study. However, as industrial dynamics literature and empirical findings (Mata and Portugal, 1994;

Demess/Cisep, 1994; Baldwin, 1995) confirm, firms fail at rates that are too high to support the contention that survival is easy.²

According to the view of human capital theorists, Portuguese textile plants, facing increasing availability of top educated and skilled individuals, considered as the most productive, should 'adapt' by becoming relatively more education/skill intensive. The flexibility of price mechanisms and the substitutability between different labour inputs would guarantee that human capital supply and demand match.³ The structural inertia observed in Portuguese textile firms demand for high levels of human capital and the concomitant failure of human capital demand to match the corresponding supply seemed to challenge the orthodox theory of human capital and calls, therefore, for alternative theoretical approaches which could account for such phenomena. Next sections discuss these alternative approaches.

1.2. Ecological approach

The ecology of organisations or population ecology theory (Hannan and Freeman, 1989), in contrast with mainstream economic theory, treats firms (or more accurately, organisations) as complex systems that have enormous limitations in terms of flexibility and speed of response, that is, systems characterised by substantial inertia. Hannan and Freeman's (1984) reformulation of the structural inertia thesis contends that selection processes favour firms with fairly static structures since these are seen as being both more reliable and more accountable than their less inert counterparts.⁴

² Another criticism (not addressed in the present paper) that one could make to the orthodox human capital theory is that education and training are seen by it as to improve performance in an unproblematic manner by making people more productive workers. It remained to be clarified, however, how some forms of skill formation have much more impact on performance for some groups of workers rather than others. Factors of production, in particular different types of workers, may not be so easily substituted for each other as human capital theory assumes. Lock-in effects on the production side, as well as the institutional context, may severely diminish the scope for substitution possibilities.

³ One is assuming here that human capital is not a consuming good, that is, it doesn't provide non-pecuniary rewards to individuals and that they therefore do not become over-skilled because of their preference for higher levels of education. Additionally, subsidisation of general human capital accumulation is not sufficiently generous that turns it into a preferred intermediate point in the labour-leisure tradeoff (for instance, as an employee one might reason that a three week training course is better than working, and if he/she is well paid to do it he/she will do so, even if he/she is absolutely certain that it will have no effect on his/her wages).

⁴ It is important to stress that structural inertia does not mean that structures subject to strong inertial forces never change. It means, instead, that organisations respond relatively slowly to the occurrence of threats and opportunities in their environments. In particular, structures of organisations have high inertia when the speed of reorganisation is much lower than the rate at which environmental conditions change (Hannan and Freeman, 1984).

This approach began and ultimately relies upon Stinchcombe's (1965) "imprinted" argument, which suggests that each 'vintage' of organisations is "imprinted" with the social, cultural, and technical features that are common in the environment at the time of the respective foundation. These imprinted characteristics, being highly resistant to change, are more likely to be reflected to a large extent in the current characteristics of populations of organisations than recent adaptations.

Moreover, the organisational ecology approach, relying on a dynamic version of Hawley's (1968) principle of isomorphism, underlines the interdependence between organisations, implying that the success of any tactic for dealing with an environmental constraint is likely to depend on the strategies adopted by the other organisations in the system.⁵

Core features tend to be more inert than peripheral ones due to the dense webs of connection which retard change (Hannan and Freeman, 1977, 1984). Employment structures lie at the core of an organisation (Baron *et al.*, 1996). Indeed, to Oi (1962) labour is a quasi-fixed factor, and the degree of fixity of labour tends to increase with the corresponding level of human capital. It seems unrealistic to suppose that firms exist in a stable equilibrium or that they continually adjust employment practices in response to changes in their external environment and internal constraints, as transaction cost economics (Williamson, 1975, 1992) implicitly assumes. Therefore, decisions relative to the accumulation of human capital, namely hiring of top educated and top skilled individuals, are likely to be characterised by substantial inertia. Thus, by admitting inertia in firm behaviour as a pro-survival characteristic, ecological approaches provide an important contribution to the attempt to explain the human capital supply-demand 'paradox' observed in the Portuguese textile industry. They, however, are mute regarding the reasons why firms make choices that lead to inert response behaviour and, therefore, provide few clues about why the genesis of variety in Portuguese textile firms routines is highly constrained.

In fact, ecological-population arguments turn to be quite static and disconnected with economic rationality. Selection works rather mechanically through a replicator mechanism, which is silent concerning the economic motivations underlying firm behaviour. It thus leaves unexplained what prevents the genesis of variety in firms routines when environmental conditions change. The inertia elements in the context of human capital decisions within the Portuguese textile industry seem to be much more enduring than ecological approaches

⁵ The principle of isomorphism holds that, in equilibrium, "units subjected to the same environmental conditions ... acquire a similar form of organization" (Hawley, 1968: 334, *cited in* Hannan and Freeman, 1989: xiii).

suggest. The increasing availability of top educated individuals in the labour market (environmental change) should, in line with ecological reasoning, lead to the exit of less ‘environmentally fit’ organisational forms and the emergence of new forms of organisations; specifically, firms characterised by relatively high intensity in human capital. Notwithstanding, the persistence within the Portuguese textile industry of firms characterised by low intensity in human capital has been striking. This fact stands therefore against the claimed regularity of industry life cycles underpinned in ecological approaches.

This paper tries to fill this gap of the population ecology theory in the sense that it seeks to explain, in an economically rational manner, *plant* behaviour in terms of human capital accumulation decisions. Specifically, it argues that the inertia observed on the human capital demand side is likely to derive from an economically rational attitude of entrepreneurs given a particular institutional context. Section 2 presents the fission risk argument, which is identified as being one potential microeconomic foundation for the inertia observed at industry level.

1. 3. Evolutionary approach⁶

The emphasis of evolutionary approaches on the co-evolution of organisational competencies, behaviours and environmental dynamics permits one to complement the somewhat economically disconnected industrial evolution perspective of ecological approaches and, most importantly, enables one to highlight the potential risk of neglecting a pro-active behaviour towards environment and thus the importance of public authorities and concomitant policy measures in such context.

Despite their emphasis on adaptation, evolutionary economists (Nelson and Winter, 1982; Langlois and Robertson, 1995; Teece and Pisano, 1998) certainly recognise the inertial properties of organisations. They account for inert behaviour in the notion of path dependence and routines, both limiting firm learning capabilities: “... highly flexible adaptation to change is not likely to characterise the behavior of individual firms” (Nelson and Winter, 1982: 135).

One of the structural characteristics of a firm, which is likely to present a high degree of persistence or inertia, is its skills and education employment structure (i.e., the demand side of human capital). The interconnection established by Nelson and Winter (1982: 124), between

⁶ Hodgson (1994) identifies evolutionary theory as a subset of a wide class of theories, variously described as ‘capabilities’, ‘resource-based’, or ‘competence-based’ theories of the firm.

skills and routines (“Routines are the skills of an organization”) highlights this fact. Routines are stable because they have evolved through experience or ‘trial and error’ rather than a rational design process and are therefore not subject to easy or straightforward alteration. Like skills, routines are partly tacit and imply a certain measure of inflexibility and path-dependence. In path-dependent systems, prior experience sets the firm on a route where subsequent developments are determined by what has gone before because, even if sunk costs are ignored, the costs of changing the path may be too high to justify making a change. Evolutionary theories have a developmental flavour. In virtually all evolutionary models, the particular firms that survive in the long run are influenced by events, to a considerable extent random events, occurring early in a model’s run. Thus, the genesis of a firm is highly sensitive to initial conditions and the early resource availability on which competence is built (Garnsey, 1998). The evolutionary nature of the learning process (Nelson and Winter, 1982) generally means that firms develop along particular trajectories determined by their initial positions, their entrepreneurial strategy and capabilities, and external stimuli. These trajectories once begun are difficult to change because firms accumulate knowledge along a certain path.

Baron *et al.* (1996) found strong path dependence in the evolution of employment systems in organisations. They claim that organisational origins matter, and initial premises that guided the design of employment relations exert an enduring effect on these companies, even as they grow, mature and, in some cases, change strategies and top management. This finding is in line with population ecology arguments (Hannan and Freeman, 1977, 1984). According to Hannan and Freeman, inertial tendencies in organisations tend to be most acute in the ‘core’ of firms where the benefits of reproducibility and legitimacy are greatest and where, because of interdependencies, even minor change has potentially enormous ramifications for other parts of the firm. Even Nelson and Winter (1982), despite arguing that inertia tends to inhibit learning processes and lower performance, do recognise that in complex systems with many interdependent parts “mutations” may have damaging effects on firm performance.

Contrasting with population ecology theory, however, the theoretical quest of evolutionary theories is for an understanding of the dynamic process behind the observed change – understanding the current state of a variable or a system in terms of *how it got there* (Nelson, 1995).

Within the evolutionary model, more productive and profitable techniques tend to replace less productive ones, through two mechanisms. First, firms using more profitable technologies

grow; secondly, more profitable technologies tend to be imitated and adopted by firms who are using less profitable ones. The more a particular technology is employed, the greater is its attractiveness relative to its competitors (dynamic increasing returns). These dynamic increasing returns derive from cumulative technologies (Nelson and Winter, 1982). With a cumulative technology, today's technical advances build on and improve upon the technology that was available at the start of the period (Arthur, 1988, 1989; David, 1985, 1992).

This aspect of cumulateness is taken account of in this paper when the argument of fission is put forward. Plants in the Portuguese textile industry emerge and reproduce existing plant employment structures in terms of human capital ('limited core of top educated and top skilled individuals and a large "reserve army" of unskilled poorly educated workers'), which in turn is the widely accepted structure at the industry level. Nevertheless, according to the cumulative technology theory, the reason that a particular technology becomes the dominant one might just simply be a matter of luck; the argument developed in this paper, in contrast, argues that the underlying reason may be a very concrete, economic one – the achievement of better performances in terms of fitness. For selection to operate consistently in favour of some characteristics rather than others, behaviour cannot be purely accidental. There must be some structural characteristics or routines of the firm, which fix, determine, mould or constraint the phenotype in some way (Hodgson, 1994). Thus, the 'active' selection factor put forward in this paper, drawing upon but going beyond the evolutionary contributions, involves selection based upon the relative effectiveness of firms in operating within the common or collective employment practice. Moreover, this gives economic soundness to the 'latent' selection factor, which reflects the common adoption of a relatively 'inert' employment practice in the line with Hannan and Freeman's argument.

2. 'Appreciative' theorising: the fission model

2.1. The fission hypothesis

The starting point of the fission hypothesis is derived from the empirical observation that in the Portuguese textile sector the pattern of human capital accumulation at establishment level increases the risk of fission and contributes to the perseverance of education and skill employment structures at industry level.⁷ In other words, the hiring of one top skilled or top

⁷ See Teixeira (2002) for more detailed information.

educated individual increases the establishment's probability of fission, regardless of the return from such a hiring. In fact, evidence provided in Teixeira (2002) does seem to suggest that the process of plant creation in the Portuguese textile industry occurs in a similar way to atomic nuclear fission.⁸ At a given moment, the nucleus of a plant (its core of top educated and skilled workers) may split, producing a new plant of a different size to the previous plant but with a similar skill and education structure.

It is assumed here (similar to the nuclear atom case) that when an additional top worker enters the firm, the risk of fission increases.⁹ Moreover, and unlike the case of the atom, there is a real possibility that the nucleus of the incumbent firm ends up with no elements, that is, all the top workers will leave the firm (radical fission) instead of the firm diminishing but continuing with a positive number (partial fission). It is argued here that the ultimate reason why the industry's skill and education patterns remain relatively inert is the risk of fission, in particular the risk of radical fission.

The "fission argument" implicitly assumes that there is a 'threshold' range (see Figure 1). The point where the left hand portion of the rectangle cuts the curve is the lower threshold (minimum number of skilled employees to avoid risks stemming from too few skilled individuals) and the right hand portion of the rectangle cuts the curve is the upper threshold (maximum number of skilled employees to avoid risks stemming from overstaffing). Below and above that range, the establishment's fitness decreases.

⁸ In physics, when a nucleus splits (fission), two (or more) daughter nuclei are formed with uneven masses, which do not add together to form the mass of the original nucleus. The process of fission is not ordered or regular, and it is uncertain (<http://www.users.bigpond.com/Sinclair/fission>).

⁹ By adding an extra neutron to the nucleus, mass is increased, and binding energy is consequently reduced to conserve energy. When the binding energy is reduced, the electrostatic repulsion within the nucleus is greater than the binding energy, and the nucleus splits (<http://wwwusers.bigpond.com/Sinclair/fission>).

Insufficient hiring of top educated/skilled workers or large amount of leavers among these workers and, at the extreme, 'radical' fission processes (ending up with no top educated or skilled workers) are likely to lead to a decline in the performance of firms. This is derived from the loss of a valuable stock of the firm's specific human capital and thus decline in productivity and potential losses in market share due to the increasing competition provoked by the creation of new firms by former top educated/skilled workers.

Increases in the number of top skilled/educated workers lead to losses in the firm's total value function. These losses are related to the risks of overstaffing and the associated potential conflicts within organisations. In this vein, 'partial' fission (loss of part, but not all, of top educated/skilled workers) is likely to improve the firm's performance.

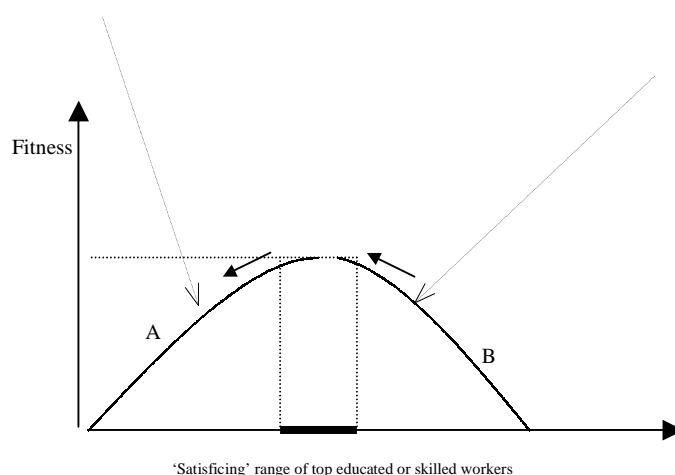


Figure 1: The fission risk and its impact on establishment fitness

Due to the risk of fission (probability of a top educated or skilled worker leaving the firm) employers tend to recruit a set number of individuals in order to avoid falling into region A of the plant's fitness function and thus suffering a decline in the corresponding probability of survival. Also this number tends to be quite limited, as employers do not want to reach region B of the same function (risk of overstaffing), and want to be able to pay these workers a sufficiently high wage to deter them from quitting and creating new (rival) firms (and thus incurring, as well, lower fitness). Increasing the wages of top educated or skilled workers tends, in line with the efficiency-wage argument, to increase their productivity rate and so restrict the possibility of further job openings at this level.¹⁰ Moreover, the increased wage rate enhances the opportunity cost of leaving the job or firm, and consequently the risk of fission diminishes. This acts, therefore, as an additional mechanism to slow down hiring of

¹⁰ This implicitly assumes that employers, given the institutional setting of wages and their budget constraints, decide on the number of workers that they intend to hire. In line with this, and following Rothschild (1960), it is assumed that wages determine productivity and not the other way around as in the neoclassical approach. That is, at the firm level, and given the institutional setting of wages, employers control how many employees they can afford, moreover they can undertake a biased (towards some specific skills) or unbiased hiring given their budget constraint.

top educated and skilled workers. Note that attempts on the behalf of employers to secure valuable existing top educated workers (and thus diminish the risk of radical fission) through increasing their already high wages, or offering them non-monetary compensations (which renders their jobs even more attractive) may act to amplify employment structural inertia. In fact, it reduces the hiring propensity as higher wages lead to less monetary resources being available for new hiring. Moreover, given the higher wage or job incentive of more education, it contributes to an ever-expanding supply of top educated labour and, therefore, an aggravation of top educated unemployment.

In practice, one should distinguish between the two ‘fission’ processes, ‘partial fission’ and ‘radical fission’. Partial fission occurs when the plant has a relative excess of top skilled or top educated workers, whereas radical fission happens when the plant has its ‘desired’ level of these types of workers. In the first case the fission may be beneficial for plant performance or fitness, whereas in the second case fission is expected, in general, to be detrimental to plant survival.

In the event of fission occurring, in particular radical fission, the plant will incur costs, namely in the form of loss of a qualified worker with associated training costs, potential loss of market share (in favour of the new competitor’s) and, ultimately, threat to the plant’s fitness or survival prospects.¹¹ In this way, the likelihood of fission influences the skill and education structures being maintained at a certain level in existing units. In addition, and given the existence of a sufficiently large pool of appropriate personnel, new organisations will tend to reproduce existing plants’ employment structures as they have been revealed to be those that are likely to lead to a ‘satisficing’ fitness level. In the end, industry employment structures in terms of human capital will remain fairly constant; that is, they will be characterised by substantial inertia.

The environment surrounding the pattern of reproduction of the Portuguese textile firms could seem, at a first glance, to resemble that of the so-called Marshallian ‘industrial districts’. Similarly to an industrial district, in the ‘core’ region of Portuguese textile (Ave Valley), there is the ability to assemble the skills, equipment and other infrastructures, which enable the working of the industry in that area. In this context, this existing set of facilities lower the entry barriers and, in this way, help the formation of new firms and support the fission hypothesis. Note, however, that the idea of the Marshallian industrial districts is to explain the

¹¹ A detailed analysis of the evolution of textile establishments’ market shares, comparing ‘new’ with ‘existing’ units, is presented in Teixeira (2002). It shows, in fact, that the emergence of new plants is accompanied by an increase in new units’ average (and accumulated) market shares and a decline in existing units’ shares.

progressive articulation between labour and capital. In the case of Ave Valley, this element of progressiveness is absent; instead one experiences a progressive static technological environment.

Specifically regarding the fission hypothesis, there are alternatives in terms of employment dynamics based upon the Silicon Valley experience. In this area, firms systematically complain about the stealing or poaching of workers. One can point, however, a feature that distinguish between Silicon Valley and Portuguese core textile area. While in the Portuguese textile case the small core of top skilled/educated workers and a large 'reserve army' of unskilled workers leads to asymmetric employment flows, in the Silicon Valley top skilled/educated in-flows/out-flows of workers are symmetric.

2.2. Inertia as economic 'rational' behaviour

Relative to firm behaviour, following an evolutionary approach (Nelson and Winter, 1982), which stands on Simon's (1955, 1959) and Cyert and March's (1963) contributions, in this paper it is assumed that firms cannot maximise over the set of all conceivable alternatives due to the complexity of problems involved. In Simon's words, rational behaviour of the firm is "bounded"; therefore, firm rules and procedures, in concrete decisions regarding human capital, cannot be characterised, as human capital theorists assume them to be, as "optimal" in the sense that they reflect the results of global calculation taking into account information and decision costs. Alternatively, firms are assumed to adopt 'satisficing' behaviour in the context of their decisions relatively to human capital accumulation trajectories. Therefore, as Cyert and March (1963) argued, a firm is unlikely to possess a well-articulated global objective function to which optimising rules would be applied.¹²

Concerning the issue of performance, reliable performance (i.e., the capacity to generate collective actions with relatively small variance in quality) requires that a firm continually reproduce its structure (Hannan and Freeman, 1984). In general, firms attain reproducibility of structure through processes of institutionalisation and by creating highly standardised routines (Stinchcombe, 1965). This, however, enhances resistance to change, i.e., inertia.

Hannan and Freeman (1984), drawing on Stinchcombe (1965), argued that the early period of a firm's existence is a crucial and fragile one, during which operating routines are worked out

¹² Alternatively, one can assume that firms are unable to see the top of the hill (the rectangle in Figure 1) and instead choose lower and upper bounds in relation to their desired fitness level. What level they choose may then be determined by the costs of recruitment which may be stochastic and time varying so that sometimes they run closer to the top and others closer to the bottom (e.g. bad and good times for employees respectively).

and external legitimacy established. Firms in their early years are subject to a “liability of newness”, or high “infant mortality rate”. They concluded that firms surviving past infancy tend to be reluctant to alter structures and processes, anticipating what might be termed a “liability of reorganisation” (Aldrich and Marsden, 1988). Due to the preference of market environments for consistent firm performance, inertia is, according to Stinchcombe (1965) and Hannan and Freeman (1984), the best behavioural alternative even in turbulent environments.¹³ Indeed, Rueff’s (1997) findings indicate limited performance advantages gained from adaptation within volatile environments, confirming the implications of (absolute) structural inertia for organisational survival. Additionally, the evolutionary theorists, Teece and Pisano (1998), stressed the risk of too much simultaneous change, because it might hinder firm competencies to conduct meaningful natural quasi-experiments. In this vein, inertia is likely to prevent risky managerial conduct and improve performance because of high routinisation and the avoidance of having to dismantle organisational structures and build others making organisational action unreliable. Therefore, inert firms are likely to outperform pro-active firms.

In the particular case of Portuguese textile firms, product markets tend to be characterised by dynamic technological stability (Lima *et al.*, 1992; Gepie, 1995; Lopes, 1996; Reigado, 1997; Vaz, 1998), i.e. firms collectively follow a strategy of incremental improvement that reinforce stability in employment practices. As the opportunities for developing major new markets are meagre (Corado and Gomes, 1995), the ability to integrate ‘innovative’ or ‘pattern disrupting’ production with the ‘trajectory-following’ process does not exist or is very limited. This issue uncovers an interesting policy implication of favouring subsidising product diversification to allow experimentation with integrating ‘innovative’ and ‘trajectory-following’ output, thus preventing a potential common future hazard, and highlights the problem in not examining the sources of demand for skilled labour.

2.3. Fitness as performance criterion

Market environments provide a definition of success for business firms, and that definition is very closely related to their ability to survive and grow (Hodgson, 1994). Organisational

¹³ The major cleavage between inertia theory and the evolutionary theory of the firm lies in the role of innovation. The benefits of inert behaviour are disputed here because it implies the risks of not adapting. Inertia is taken as beneficial only in stable environments while it is likely to be harmful in unstable ones. In these latter it is often argued that firms have to learn in order to survive (Nelson and Winter, 1982; Meeus and Oerlemans, 2000). Haveman (1994) points out that, especially in unstable and uncertain environments, selection pressures will favour flexible organisational forms that adjust to perform consistently.

ecologists, for instance, view competitive processes as optimising fitness, that is, survival capability. The concern of ecologists, however, is most heavily concentrated on the probability of survival of the organisational form, not the individual organisation.

Survival is, according to Winter (1964), the fate of individual organisations, and their market share is a measure of their viability. The survival (i.e., resistance to selection) of adaptable organisational forms depends on the nature of the environment and on the competitive situation (Freeman, 1982). Therefore, industry structure and the associated competitiveness conditions are likely to constitute important factors for plant fitness. Mata and Portugal (1994), for instance, found that higher hazard rates are found in high entry rate industries and that multi-plants tend to survive longer.

The first studies on the demographics of firms (Simon and Bonini, 1958; Hymer and Pashigian, 1962; Mansfield, 1962) and a substantial number of recent ones (*e.g.*, Ghemawat and Nalebuff, 1990; Lieberman, 1990; Dunne and Hughes, 1994) were mainly concerned with the relation between survival and size. A rather consensual finding is that smaller firms have relatively high death rates.¹⁴ Mansfield (1962), however, recognised that his regressions omitted important variables, especially the mobility of management and the workforce, in explaining plant survival capacity.

Another finding related to survival capacity is that average wages grow less rapidly in plants that will soon close. According to Hamermesh (1988), negative demand shocks have to be met with far below-average wage increases to avoid a higher probability of shutdown. This author also found that additional years of schooling, *ceteris paribus*, reduce the probability of plant closure whereas the impact of additional years of worker tenure on survival is positive but not significantly so. Carneiro (1995), analysing Portuguese manufacturing establishments' survival probability, found that wages and age of establishments perform an important role in plant survival, whereas average worker seniority (a proxy for specific human capital investments) is only favourable within the first 5 or 7 years that workers are working in the plant.

The option for using the fitness criterion instead of other more commonly used criteria, such as productivity or profit indicators, is related both to its theoretical soundness (in the context of evolutionary and ecological approaches) and the limitation of the latter indicators, which

¹⁴ Jovanovic (1982) argued that firms differ in size because some discover that they are more efficient than others. Efficient firms grow and survive whereas inefficient ones decline and fail.

have an implicit sample-survival bias.¹⁵ Moreover, the emphasis on establishments' human capital accumulation patterns attempts to fill the existing gap in the empirical literature on plant demographics, in the guise of the neglect of human capital dynamics. Thus, in the following section, the 'fission empirical model' is rationalised in terms of establishment survival capacity or fitness. In other words, it aims to estimate the impact of establishments' human capital accumulation patterns, namely the loss of all top educated and/or top skilled workers ('radical fission'), on establishment fitness. In order to control for important factors (besides human capital) likely to influence establishment fitness, factors taken as relevant in the existing literature on the demographic dynamics of firms (e.g., industry, size, age, wage dynamics, etc.) are introduced into the model.

3. The estimation of the fission model

3.1. Econometric specification

The aim here is to collect evidence on the relation between human capital accumulation patterns and the corresponding survival probability of establishments. In particular, the work undertaken is intended to evaluate the empirical relevance of fission processes (in terms of education and skills) for the fitness of textile establishments.

The nature of data observed relative to the dependent variable [Establishment survived? (1) Yes; (0) No] dictates the choice of the estimation model.¹⁶ The approach used is to analyse each situation in the general framework of probabilistic models.¹⁷

$Prob(\text{event } j \text{ occurs}) = Prob(Y=j) = F[\text{relevant effects: parameters}]$.

In the model of establishment survival, during a given period, the establishment either survived ($Y=1$) or did not ($Y=0$). Moreover, it is believed (cf. Teixeira, 2002) that a set of factors, such as human capital accumulation patterns, size, industry, and workforce composition, among other variables, gathered in a vector X , explain the outcome, so that

¹⁵ Note, however, that in the case study analysis productivity growth is used as the criterion for firm performance. Notwithstanding this, here in a sample of existing or surviving firms, the issue of present or past survival capacity is not addressed.

¹⁶ Conventional estimation techniques (e.g., multiple regression analysis), in the context of a discrete dependent variable, are not a valid option. Firstly, the assumptions needed for hypothesis testing in conventional regression analysis are necessarily violated – it is unreasonable to assume, for instance, that the distribution of errors is normal. Secondly, in multiple regression analysis predicted values cannot be interpreted as probabilities – they are not constrained to fall in the interval between 0 and 1.

¹⁷ The logistic regression model is also preferred to another conventional estimation technique, discriminant analysis. According to Hosmer and Lemeshow (1989), even when assumptions required for discriminant analysis are satisfied, logistic regression still performs well.

$$\Pr ob(Y = 1) = F(X, \beta)$$

$$\Pr ob(Y = 0) = 1 - F(X, \beta)$$

The set of parameters β reflects the impact of changes in X on the probability of survival. For example, among the factors that are of interest in this paper is the marginal effect of human capital accumulation patterns, in particular the fission associated with top educated or skilled workers, on the probability of establishment survival (proxy for establishment fitness). The problem at this point is to devise a suitable model for the right-hand side of the equation.

The empirical assessment of the fission argument is based on the estimation of the following general logistic regression:¹⁸

$$P(SURV) = \frac{1}{1 + e^{-z}}$$

$$Z = \beta_0 + \underbrace{\beta_1 RF + \beta_2 PF + \beta_3 IN0 + \beta_4 INP}_{\text{Human capital accumulation patterns}} + \underbrace{\beta_5 S2 + \dots + \beta_{12} S9}_{\text{Size dummies}} + \underbrace{\beta_{13} PREP + \dots + \beta_{21} OTHER}_{\text{Industry dummies}} + \beta_{22} E8488 + \beta_{23} LNWAGE + \beta_{24} WAGE8488 + \beta_{25} MULTES + \beta_{26} PAGE25 + \beta_{27} F_W + \varepsilon_i$$

The definition of the variables is presented in Table 1.

In order to have a more straightforward interpretation of the logistic coefficients it is convenient to consider a rearrangement of the equation for the logistic model, in which the logistic model is rewritten in terms of the odds of an event occurring. Writing the logistic model in terms of the odds, one obtains the *logit* model

$$\log\left(\frac{\Pr ob(SURV)}{\Pr ob(NOSURV)}\right) = \beta_0 + \underbrace{\beta_1 RF + \beta_2 PF + \beta_3 IN0 + \beta_4 INP}_{\text{Human capital accumulation patterns}} + \underbrace{\beta_5 S2 + \dots + \beta_{12} S9}_{\text{Size dummies}} + \underbrace{\beta_{13} PREP + \dots + \beta_{21} OTHER}_{\text{Industry dummies}} + \beta_{22} E8488 + \beta_{23} LNWAGE + \beta_{24} WAGE8488 + \beta_{25} MULTES + \beta_{26} PAGE25 + \beta_{27} F_W + \varepsilon_i$$

The logistic coefficient can be interpreted as the change in the log odds associated with a one-unit change in the independent variable.

$$\left(\frac{\Pr ob(SURV)}{\Pr ob(NOSURV)}\right) = e^{\left[\underbrace{\beta_0 + \beta_1 RF + \beta_2 PF + \beta_3 IN0 + \beta_4 INP}_{\text{Human capital accumulation patterns}} + \underbrace{\beta_5 S2 + \dots + \beta_{12} S9}_{\text{Size dummies}} + \underbrace{\beta_{13} PREP + \dots + \beta_{21} OTHER}_{\text{Industry dummies}} + \beta_{22} E8488 + \beta_{23} LNWAGE + \beta_{24} WAGE8488 + \beta_{25} MULTES + \beta_{26} PAGE25 + \beta_{27} F_W + \varepsilon_i \right]}$$

Then e raised to the power β_i is the factor by which the odds change when the i^{th} independent variable increases by one unit. If β_i is positive, this factor will be greater than 1, which means

¹⁸ Teixeira (2002) provides the formal deduction of the *logit* model present here.

that the odds are increased; if β_i is negative, the factor will be less than one, which means that the odds are decreased. When β_i is 0, the factor equals 1, which leaves the odds unchanged.

3.3. Results of estimation

Statistical information used in this section is based on unpublished data from a Portuguese survey, “Quadros de Pessoal”.¹⁹ The statistical department of the Portuguese Ministry for Qualification and Employment (DE_MQE) has collected these data on a yearly basis since 1982.²⁰ “Quadros de Pessoal” is a survey that is compulsory for every Portuguese firm with at least one wage-earner. It thus covers almost the whole population of Portuguese firms with paid employees. The database employed to compute measures presented in this work includes a file for each year of the study (1984, 1988 and 1992).²¹ This file includes all establishments classified in the textile industry.²²

The Table 1 presents a summary version of the estimated logistic regressions in ‘preferred’ estimated models for both top educated and top skilled employment categories.²³ The choice of these ‘preferred’ models was based on goodness-of-fit measures, namely the log-likelihood statistic and Hosmer and Lemeshow measure.²⁴ In these models estimates associated with ‘radical fission’ and ‘inert zero’ categories are in general statistically significant, whereas ‘partial fission’ and ‘inert positive’ categories fail to be statistically significant.²⁵

¹⁹ The author acknowledges Dra. Maria João Rebelo and Dr. Artur Simões, directors of the statistical department of the Portuguese Ministry for Qualification and Employment, for the permission to use this database.

²⁰ The former designation of DE_MQE was DEMESS.

²¹ The reason for not choosing an earlier period was because of the survey’s initially poor coverage. Substantial changes in data collection methodology after 1992 influenced the choice of the last period. Despite the small number of periods considered, the eight-year period seems to be sufficiently wide to permit statistical inferences to be drawn on the topic pursued here.

²² The database provides rich and comprehensive information about Portuguese textile establishments. However, it also presents some problems that must be minimised (through feasible correction) to permit a more consistent and meaningful analysis. These problems and how they are overcome are discussed in Teixeira (2002).

²³ The estimated complete logistic regressions are presented in Teixeira (2002).

²⁴ The log-likelihood statistic is analogous to the error sum of squares in multiple regression and, as such, is an indicator of how much unexplained information there is after the model has been fitted. It follows, therefore, that high values of the log-likelihood statistic indicate poorly fitting statistical models, because the higher the value of the log-likelihood, the more unexplained observations there are. Hosmer and Lemeshow’s (H&L) measure might be considered an analogue to the R^2 value in linear regression; it is the proportional reduction in the absolute value of the log-likelihood measure and as such it is a measure of how much the goodness-of-fit improves as a result of the inclusion of the predictor variables. It can vary between 0 (indicating that the predictors are useless for predicting the outcome variable) and 1 (indicating that the model predicts the outcome variable perfectly). H&L’s goodness-of-fit statistic tests the hypothesis that the observed data are significantly different from the predicted values from the model. So, in effect, one wants a non-significant value for this test (because this would indicate that the model does not differ significantly from the observed data). A non-significant value for the H&L test is indicative of a model that is predicting real world data fairly well.

²⁵ Estimates presented in Table 1 draw on the assumption that missing values on education and skills categories are zero. In Teixeira (2002) this issue is discussed in a great detail.

Estimation results show that even when one controls for establishments, industry, employment and wage dynamics, length in business and employment gender and youth composition, for both top educated and top skilled cases, the odds of survival are significantly lower for establishments that suffered radical fission processes when compared with establishments that expanded the number of such workers or those that maintained an inert zero behaviour, that is, did not have any top educated or top skilled workers in the period under study (1984-1988).

In fact, establishments that present inert behaviour in terms of human capital accumulation perform better than establishments that in the initial period had some positive number for top workers but four years later ended up with none. Therefore, in the top educated case, the odds of survival for radical fission establishments are estimated at 0.534 times those for establishments that expanded; whereas in case of inert zero establishments the corresponding odds of survival are estimated to be 0.695 (in the case of top skilled, the respective figures are similar at 0.552 and 0.607).

In this vein, although in the short run expanding seems to be the most profitable alternative (in terms of fitness, at least), in the medium run, given the highly detrimental impact of radical fission on fitness, establishments may improve their survival prospects by instead maintaining an inert (zero) behaviour. Moreover, in the particular case of top educated employment, the evidence seems to indicate that inert positive behaviour is, in fact, even more profitable than expanding. Notwithstanding this, as already referred to above, this conclusion lacks statistical significance. For top skilled cases, and taking into account the same limitation, inert positive behaviour presents odds of survival substantially higher than radical fission, though lower than the expanding alternative.

Note that although the ‘reverse causality’ argument could provide an alternative explanation for the empirical evidence gathered here, it is discarded based on further evidence gathered from the survey to recently created textile firms (*cf.* Teixeira, 2002). According to this later, the “prospective closure” or “economic difficulties” of the former employer of the respondents (owners of newly created textile firms) was considered important or very important motive for creating their present firm in only 22% of cases; the vast majority (78%) of the new owners claimed that the most important reasons for starting the new business (in competition with their former employer) were the existence of a business opportunities, desire for independence or expectation of higher incomes. This isolated piece of evidence tends thus to support the argument of fission and to exclude alternatives.

It is pertinent to point here that an important aspect, neglected by ecological approaches, but clearly argued by Nelson and Winter, concerns the fact that, although necessary and desirable features under plausible states of the world (as reflected in the circumstances surrounding the Portuguese textile industry for the period in study), those common or collective patterns might be also potentially risky: "... the routinized control system may be deployed so massively that it has the collateral effect of impeding adaptation when adaptation is actually necessary" (Nelson and Winter, 1982: 117). In this vein, the stability of routines may ultimately endanger firm survival prospects. Inertia may inhibit learning processes and lower performance because of growing deficiencies in competences to align behaviour with environmental demands. The relative inflexibility to the new selection environment, however, is not revealed before it is experienced. In the particular case of the Portuguese textile industry, the common employment practices, which under the present selection environment are fitness enhancing, may constitute a serious common hazard under new selection environments.²⁶ This possibility suggests the need for a pro-active industrial-education policy by Portuguese authorities, which may attenuate or even eliminate such common hazards by diversifying the product markets in which firms seek to operate. Concrete policy recommendations in this domain, however, are beyond the scope of the present paper and would themselves be an interesting topic for further research.

4. Conclusion

This paper aimed to develop and test empirically the fission model. The fission hypothesis states that plants' reproduction process occurs in a similar way to atomic nuclear fission. Thus, at a given moment, the 'nucleus' of the plant, constituted by its core of top educated and top skilled workers, may split, originating a new plant with a similar education and skill structure. It is argued then that due to this fission risk, plants would tend to maintain a

²⁶ The following example illustrates the problem. Prior to 1974, the relatively low and stable cost of energy led many firms to adopt relatively energy-intensive technologies. The selection factors operating in this environment had much more to do with how firms utilised the technologies than with their relative energy efficiencies (investments to gain efficiency in non-energy areas might always have a higher internal rate of return than energy-conserving investments). The dramatic change in relative price of energy in 1974 (since reversed of course) revealed the common hazard. In the new selection environment, the relative capacity of firms to adjust was tested in ways that they had not previously been leading to substantially greater variance in their performance and setting off a major disequilibrium marked by inflationary spirals and the 'hard' landing of the 1981 recession. However, prior to 1974, no one would be able to 'prove' that pursuing the goal of energy efficiency or abilities to flexibly adapt energy usage would constitute a serious common hazard. The end of the GATT agreement in 2005 and the accession of eastern European economies to the EU threaten to undermine Portugal's market in textile products with lower wage competition, and thus question the desirability of present common employment practices.

bifurcated employment structure characterised by a limited core of top educated and top skilled workers and a large ‘reserve army’ of undifferentiated and low educated individuals. Implicitly it was assumed that the existence of a limited number of top educated and top skilled workers would yield ‘satisficing’ levels of fitness. Also that the risk of fission would produce new establishments, which, in turn, would profit (in terms of fitness) by imitating existing plants’ employment structures. In this vein, the mechanism of establishment reproduction would explain the observed inertia at the industry level on the human capital demand side, and thus the human capital paradox.

In order to empirically assess the pertinence of the fission argument, concerning the ‘profitability’ of maintaining inert behaviour in terms of the hiring of individuals with high levels of human capital (i.e., top educated and top skilled workers), and the existence of a limited core of such individuals (which would permit the establishment achieving a given ‘satisficing’ level of performance), a probabilistic model of establishment survival was specified that took into account the accumulation pattern of human capital, in particular the fission risk.

The estimated logistic model, based on the whole population of the Portuguese textile establishments that were in business in the period 1984-1988 (whether or not they survived until 1992), provides statistical evidence that corroborates the fission argument. In fact, taking a dynamic perspective, there is enough evidence that it is more profitable for an establishment, in terms of fitness or survival capacity, to maintain inertia (characterised by employment of no top educated or top skilled workers) than to hire an individual with high levels of human capital which would run the risk of eventually suffering a fission process. This evidence is stronger in the case of top educated than top skilled workers.

To sum up, the main research findings are: 1) ‘fission risk’ is an important reason for the (relative inert) behaviour of firms regarding the accumulation of high levels of human capital; 2) the composition of human capital accumulation is shaped by demand, which is more socially constructed than admitted in the mainstream economics; and 3) the successful employment common practice within the Portuguese textile industry hides a potential common hazard likely to materialise in the event of unexpected changes in the environmental constraints faced by firms.

Table 1: Human capital and establishment fitness in the Portuguese textile industry - logistic estimates of the odds of establishment survival

Indep. Variable	Definition	Coef. estimates and significance	Top Educated	Top Skilled
RF	'Radical fission' – establishments that between 1984 and 1988 lost all their top educated (skilled) workers;	Exp(β)	0.534	0.552
		Significance	0.047	0.037
PF	'Partial fission' – establishments that between 1984 and 1988 lost some of their of top educated (skilled) workers, i.e., the number of top educated (skilled) workers in 1988 is less than that for 1984 but still positive;	Exp(β)	1.390	1.198
		Significance	0.444	0.536
INZ	'Inert zero' – establishments that in neither period (1984 and 1988) had any top educated (skilled) workers;	Exp(β)	0.695	0.607
		Significance	0.067	0.008
INP	'Inert positive' – establishments that maintained the same number of top educated (skilled) workers in 1984 and 1988; ¹	Exp(β)	1.030	0.729
		Significance	0.917	0.171
E8488	Equals 1 if the establishment maintained or expanded its total employment between 1984 and 1988 and 0 otherwise	Exp(β)	1.923	1.694
		Significance	0.000	0.000
LNWAGE84	The natural logarithm of the average monthly base remuneration in real terms in 1984 ²	Exp(β)	0.974	1.232
		Significance	0.954	0.593
WAGE8488	The growth rate of the average monthly base remuneration in real terms between 1984 and 1988	Exp(β)	1.008	1.004
		Significance	0.089	0.391
LNAGE	The natural log of the highest length of tenure of workers within the establishment in the reference period	Exp(β)	1.305	
		Significance	0.001	
MULTES84	Assuming the value 1 in the case of an establishment belonging to a single-establishment firm and 2 if it belongs to a multi-establishment firm in the reference period	Exp(β)	0.788	
		Significance	0.380	
PAGE2584	The ratio of the number of employees aged 25 or under in establishments' total employment in 1984	Exp(β)	0.999	
		Significance	0.751	
F_W84	The ratio of the number of women working in the establishment to total employees in 1984	Exp(β)	0.996	
		Significance	0.128	
CONST.		Exp(β)	1.763	1.415
		Significance	0.701	0.790
Dummy variables				
Size ³			No	No
Industry ⁴			Yes	Yes
N			1395	1417
Survived			1039	1055
Died			356	362
-2Log Likelihood			1517.7	1563.7
Hosmer and Lemeshow test				
Chi-Square			3.53	8.49
Sig.			0.90	0.39
No. Iterations			3	3

Note: Computations made by the author based on unpublished data from "Quadros de Pessoal".

¹ EXP ['Expanding'] – establishments that increased the number of their top educated (skilled) workers between 1984 and 1988 – is the default category.

² I.e., the sum of real monthly base remunerations earned by establishment i 's workers in March of year t , divided by the number of wage earners in the service of establishment i in the same reference period; wages were computed at 1985 constant prices, using the consumer price index as deflator (Source: INE and Banco de Portugal); Base remuneration is taken to be the gross amount that each worker has the right to receive in the reference month relative to normal working hours.

³ S1, establishments with one to five employees [1, 5] is the default; S2 - establishments with six to ten employees [6, 10]; S3 - establishments with eleven to nineteen employees [11, 19]; S4 - establishments with twenty to forty-nine employees [20, 49]; S5 - establishments with fifty to ninety-nine employees [50, 99]; S6 - establishments with one-hundred to one-hundred and ninety-nine employees [100, 199]; S7 - establishments with two-hundred to four-hundred and ninety-nine employees [200, 499]; S8 - establishments with five-hundred to nine-hundred and ninety-nine employees [500, 999]; S9 - establishments with over one thousand employees [1000, ...].

⁴ PREP - preparation of textiles; WOOL - spinning, weaving and finishing of wool and wool mixed fibres; MADE-UP - other made-up textiles; HT - home textiles; EMB - embroideries; KNIT - manufacture of knitted articles; RUG - carpets, mats and rugs; ROPES - ropes, cables and nets; OTHER - other textiles; the default industry is COTTON (spinning, weaving and finishing of cotton, artificial and synthetic fibres).

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