Penrose's productive opportunity and the analysis of the firm

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Introduction

The main objective of this contribution is to discuss Penrose's idea of a firm's productive opportunity (hereafter PO) and reinterpret aspects of PO functioning through the lens of more recent contributions to economics, and in particular ideas from modern behavioural economics and complexity theory. This discussion inevitably leads into a consideration of more general matters involving the analysis of the firm. The focus on a firm's PO places a necessary constraint on the material presented here. In terms of Penrose's work the analysis is restricted to the *Theory of the Growth of the Firm* (hereafter TGF)[1], ignoring her other contributions to economics. This restriction is no real misrepresentation of Penrose's work as TGF is clearly her *magnum opus*[2]. But, in addition, this contribution is not a general review of TGF and so will not discuss matters such as the direction of firm expansion and diversification. Apart from recognising inevitable space constraints, the focus on a firm's PO reflects the view presented by, for example, Fransman (1994) and Foss (2002) that it is arguably the key concept in TGF.

The rest of the discussion is organised as follows. In the next section there is a background discussion on Penrose's idea of a firm's PO and related matters. The following section presents a reconsideration of the idea of a PO. This discussion presents the idea of a PO spectrum the end points of which are open and closed POs, where open and closed refer to the openness and closure with respect to new ideas. In the final substantive section the PO discussion is linked to the wider area of firm capabilities. In addition the framework is developed to include demand-side cognitive bias as well as supply-side. This allows four particular approaches to PO functioning to be identified. Finally brief conclusions are drawn.

Productive Opportunity: background discussion

A key motivating feature of Penrose's work on the firm is that

> ... the fundamental assumptions on which the analysis rests are chosen with a view to their applicability in the 'real world'..." (p3)

[1] The discussion presented here uses the second edition of TGF. This is identified in the list of references as Penrose (1980/1959). All quotations in the text that are not otherwise identified are from this edition of TGF.

[2] In terms of indicative metrics on this, TGF appears with 20000+ cites on Google Scholar.

As such Penrose's work is part of a wider tradition involving the analysis of "real" firms (Dietrich and Krafft, 2011, 2012; Ravix, 2002). For example, Coase (1937, 1993) is part of this wider tradition that we need a "realistic" theory of the firm rather than the "blackboard economics" (Coase 1991) that characterises much writing. The somewhat standard view, as argued by Demsetz (1983), is that we should not

> ... confuse the firm of economic theory with its real-world namesake. The chief mission of neoclassical economics is to understand how the price system coordinates the use of resources, not the inner workings of real firms. (p377)

But this view creates a rather artificial barrier between the "theory of the firm" (or the technical firm where profit maximization issues are discussed) and the "economics of the firm" (or the institutional firm where the focus is more on the organisation of production in itself). The result is that the analysis of real firms is viewed as an aspect of institutional analysis, and hence part of the economics of the firm, because technical firms are viewed only as an aspect of price theory. This leaves the "theory of the firm" in its own hermetically sealed price theory box.

Penrose to some extent is in accordance with this standard view, but her analysis particularly involving a firm's PO suggests important differences. Penrose appears to agree with Demsetz:

> ... much confusion has arisen because of a failure to distinguish the different meanings in economic analysis of the term 'firm'; the economist's firm in the 'theory of the firm' is not at all the economic institution that ordinary people would think of as a firm. (p7)

Furthermore:

> ... the 'firm' in the 'theory of the firm' ... provides an unsuitable framework for a theory of the growth of firms, ... we shall not be involved in any quarrel with the theory of the 'firm' as part of the theory of price and production, so long as it cultivates its own garden and we cultivate ours. Much confusion can arise from the careless assumption that when the term 'firm' is used in different contexts it always means the same thing. (p10)

Finally on this theme:

> ... to the theorist concerned with the growth of the firm, defined, say, as an administrative organization in the real world ... it becomes necessary to use a very different concept of the firm and little is gained by tortuously trying to

> force adaptation of the theory of the firm merely because it has proved to be a valuable concept for a different purpose... [F]or [the firm as a growing organization] the 'firm' must be endowed with many more attributes than are possessed by the 'firm' in the theory of the firm... (p14)

To generalise Penrose's perspective presented here: just as there is no single thing called the firm, because it depends on the analytical purpose for which it is being used, there is no single thing called a real firm. So, for example, Coase's real firms that bolt onto an equilibrium reasoning, by emphasising the significance of transaction costs in markets, are different from process based or evolutionary real firms (Ravix 2002). Both, in principle, are correct for their analytical purposes, as long as they do not stray from their specific analytical arena. Hence, as is clear from the previous quotation from TGF, a real firm analysis aimed at understanding firm growth requires "many more attributes" than an equilibrium based analysis. But at a sufficiently abstract level there is a common definition: real firms are both technical (in a focus on production) and institutional (in a focus on organisation) (Dietrich and Krafft, 2012). But, of course, the analytical tools required to examine production and organisation can differ depending on particular questions being asked and analytical issues being solved. In Penrose's words:

> The business firm, as we have defined it, is both an administrative organization and a collection of productive resources... (p31)

This allows us now to understand the analytical significance of Penrose's PO. If real firms are viewed as both "administrative" and "productive", or equivalently as institutional and technical, understanding firm functioning requires an inter-linkage between these two aspects of the firm. One analytical response here is to claim that administrative and productive activities are separable. But this requires an ex-post equilibrium based logic (Dietrich, 1994; Dietrich and Krafft, 2011) or an assumption of separability. For example, from a standard transaction cost perspective the characteristics of the real goods or services being produced are independent of the institutional analysis. In Williamson's (1985, p 22) words: "Holding the nature of the good or service to be delivered constant, economizing takes place...". But there is no such assumption in TGF because the idea of a firm's PO creates a link between the

firm as an administrative organisation (i.e. the institutional firm) and the firm as a collection of productive resources (i.e. the technical firm).

This inter-linkage between the two aspects of real firms requires a distinction between a firm's "resources" and the "services" derived from the resources. Resources are "things that the firm buys, leases, or produces..." (p24). But resources are not inputs into production; instead it is services that are inputs that are derived from resources. The mapping from resources to services is defined by a firm's PO:

> The productive activities of such a firm are governed by what we shall call its 'productive opportunity', which comprises all of the productive possibilities that its 'entrepreneurs' see and can take advantage of." (p31)

Note the final part of this quotation: a firm's PO involves what can be seen as well as taken advantage of. This aspect will be core to later discussion that will use the modern idea of cognitive bias that guides what can be seen. For the moment consider a second aspect of this quotation: use of the term entrepreneurs that Penrose places in parentheses. Entrepreneurial services are an important part of a firm's changing PO, and are viewed as different from managerial services (although the same people may be involved). The former involve the development of new ideas. The latter involve the execution of new ideas as well as the management of current activities. Hence entrepreneurship is not viewed as heroic, in the Schumpeterian sense, but as a somewhat ordinary part of a firm's PO. As Penrose notes:

> The Schumpeterian 'entrepreneur', though more colourful and identifiable, is too dramatic a person for our purposes. (p36)

A firm's PO is explicitly assumed to NOT depend on managerial incompetence. Instead it is constrained by three factors: what a firm can <u>see</u>, what it is <u>willing</u> to act on and what it is <u>able</u> to respond to. It follows that "sober calculations" are downplayed, instead "psychological predispositions", "entrepreneurial bias", "intuition and imagination" and "self-confidence" are emphasised. The resulting behaviour in complex conditions is best not analysed using optimising methods (Dosi and Marengo, 1994). Instead an emphasis on knowledge and problem solving becomes analytically central (Marengo, 1995). This would seem to identify Penrose as Marshallian in terms of her analytical roots (Loasby, 1991, 2002).

We now arrive at a core feature, for the current discussion, of the Penrose framework. As a firm's PO is based in psychological factors, with intuition etc. being important, a distinction is drawn between what is "objective" and what is "subjective" for any firm:

> Although the 'objective' productive opportunity of a firm is limited by what the firm is able to accomplish, the 'subjective' productive opportunity is a question of what it thinks it can accomplish. (p41)

Furthermore, analysis of the subjective PO allows (in principle) prediction of individual firm behaviour:

> If we can discover what determines entrepreneurial ideas about what the firm can and cannot do, that is, what determines the nature and extent of the 'subjective' productive opportunity of the firm, we can at least know where to look if we want to explain or to predict the actions of particular firms. (p42)

This distinction between subjective and objective POs is analysed below using the post-Penrose idea of cognitive bias. Before considering this (re)interpretation of Penrose's work a few additional key features of the TGF framework can be considered that provide useful background for the later discussion. First, the objective environment is a real constraint to firm activity:

> In the last analysis the 'environment' rejects or confirms the soundness of the judgements about it, but the relevant environment is not an objective fact discoverable before the event; economists cannot predict it unless they can predict the ways in which a firm's actions will themselves 'change' the relevant environment in the future. In any event, what the economist sees may be very different from what an individual firm sees, and it is the latter, not the former, that is pertinent to an explanation of a firm's behaviour. (p41)

As Penrose removes incompetent decisions from her analysis (as is clear from the earlier cited comment), this environmental selection must be based on the effectiveness of perception, intuition and (perhaps) luck, although the latter is not explicitly part of her framework. But it is clear that there is a continuum from effective entrepreneurship, at one extreme, to incompetence at the other. Hence Penrose seems to be restricting her analysis to some mid-point on such a continuum.

Having introduced the possibility of environmental selection, Penrose is clear that there is no single view, or strategy, that is competent. This implies that firm behaviour cannot be understood as a straightforward mapping from environment to strategy, not least because the environment is not exogenous. Instead behaviour is in a fundamental sense determined by internal firm activity i.e. the PO:

> Firms not only alter the environmental conditions necessary for the success of their actions, but, even more important, they know that they can alter them and that the environment is not independent of their own activities. Therefore, except within very broad limits, one cannot adequately explain the behaviour of firms or predict the likelihood of success merely by examining the nature of environmental conditions. (p42)

This conceptualisation of firm behaviour, and the role of a (subjective) PO, leads on to one final matter considered in this section. Penrose uses Boulding's (1956) idea of the environment as an image:

> We shall be interested in the environment as an 'image' in the entrepreneur's mind. (p42)

As Ravix (2002) makes clear, in Boulding's work there is no objective environment. Instead behaviour does not depend directly on the environment but on the image that is built up. In addition a distinction is drawn between the image of the environment and subjective messages that are information received. Each message can, in principle, change the image of the environment. Foss (2002) offers an interpretation of Penrose's use of Boulding's image, in terms of more modern organisation theory (e.g. Weick, 1995), that the environment is "enacted" rather than being objective. But this possible enactment of the environment sits uneasily with Penrose's view (cited earlier that

> In the last analysis the 'environment' rejects or confirms the soundness of the judgements about it... (p41).

It is clear from TGF that Penrose is engaged in a debate with economics, a feature of the work that still applies today. Hence a more economically grounded interpretation of "image" is suggested below in terms of firm decisions being "framed" because of cognitive biases. Furthermore this is consistent with more modern image theory (e.g. Beach, 1993) that emphasises the importance of decision maker cognitive

development. Of more central concern for the current discussion is that it also echoes what emerges from contributions in complexity theory, i.e. search is more often local rather than global in the technological space. The ability to engage in a search process within spaces that are distant from the original starting point is likely to generate breakthroughs stemming from the combination of brand new components (Nightingale, 1998; Fleming, 2001). In addition, complexity theory suggests that the knowledge base of a firm can be analysed in terms of three factors: variety (informational entropy), coherence (weighted average relatedness) and similarity (cognitive distance) (see Antonelli, Krafft, Quatraro, 2010; Krafft, Quatraro, Saviotti, 2011, 2014a, 2014b; Colombelli, Krafft, Quatraro, 2013, 2014). It follows that the combination of framing and complexity facilitates an analysis of a firm's PO that recognises its subjective (framed) nature but also that is a part of firm (not just individual) decisions that require search and learning based on coherence and similarity as well as variety.

One final substantive point can be emphasised in this section. The use of the phrase "in the last analysis" in the quotation just cited suggests that Penrose understands environmental selection as a long-run issue but that in the short-run the subjective PO is important. This is consistent with Ravix (2002) when he points out that the only circumstances in which a past event cannot be changed by firm action is when it is irreversible. While this observation is important it leaves open where such irreversibility is located in the functioning of the firm. It will be suggested below that the PO itself may generate irreversible decisions because of decision heuristics. This allows a long-run environmental impact to which firms may not be able to adjust.

POs and team activity

This section considers the nature of a firm's PO using the lens of decision heuristics and cognitive bias along with related ideas from complexity theory. This connection between cognitive issues and Penrose is somewhat natural because as Foss (2002) argues differential cognition is at the core of the idea of a firm's PO. Furthermore, Foss suggests that it is in many ways closer to (original) behavioural theory (e.g. March and Simon, 1958; March, 1988) than other schools of thought in economics. But arguably the same reasoning applies to the creation of a connection with more recent cognitive based contributions to economics.

Before exploring the substantive issues involved we can reject one possible interpretation of Penrose's framework. The subjective-objective PO distinction is not ex-ante and ex-post with an adjustment lag between the two. More precisely an ex-ante / ex-post interpretation is not consistent with Penrose's reasoning:

> Thus a 'static' analysis can be an appropriate method of exploring the conditions of 'equilibrium'. The productive opportunity of the firm *will* be fixed if we assume that no change takes place in external conditions, nor any change in knowledge and, as a consequence, no change in the internal supply of productive resources. (p55)

It is clear from this quotation that if the PO is fixed we might reasonably interpret the subjective-objective distinction as an adjustment lag i.e. a long-run static analysis would be appropriate based on a fixed objective PO. But even ignoring exogenous environmental developments, the functioning of a firm's PO involves knowledge creation that changes the subjective and objective PO. In addition any PO change will itself impact on the environment. In terms of modern behavioural economics, the fixity of a firm's PO allows replication of decisions and hence convergence (through trial and error and learning) to a long-run static equilibrium. But without replication the subjective decisions have a degree of independence.

Modern behavioural economics, and the psychological experiments upon which it based, suggests that in complex and uncertain conditions two different cognitive "systems" guide decision making: system one and system two (Cartwright, 2014; Kahneman 2011; Kahnemann et al 1982), although Thaler and Sunstein (2009) use the terms "automatic" and "reflective" to describe the same cognitive characteristics. System two (or reflective) decisions are controlled, effortful, deductive and slow. In short they are "costly" in terms of time and effort. System one (or automatic) activity is uncontrolled, effortless, fast and unconscious and as such avoids the time and effort (i.e. costs) involved with system two decisions. System one seems to use the oldest (in evolutionary terms) parts of the brain that humans share with other animals. In addition it produces the decision making rules of thumb and biases to be considered shortly.

As Nooteboom (2012) emphasises, in evolutionary terms, including economic evolution, system one activity may (not will) have an advantage over system two. While the former is economically irrational, taking into account survival conditions that require fast interpretation and decisions making in response to opportunities and threats, it may be procedurally rational. But system one and two activity are not independent, instead they can interact. The possibility of replication of decisions, in unchanged conditions, that through trial and error and learning can approach a static solution is one such example. But note that the unchanged conditions minimises the significance of the costs and effort of system two activity. A second example is that training can be used to control the automatic nature of system one activity. But, of course, such training is costly. Hence the more that system one is controlled the greater the required training costs involved. This latter idea is used below, in a team context, to talk about different POs that may embed learning and adjustment in firm activity.

In complex and uncertain conditions (i.e. with real world conditions), system one activity tends to guide or dominate decision making, ignoring the possible effects of training and learning. This has allowed psychologists and modern behavioural economists to identify three characteristic decision making rules of thumb, or decision heuristics that produce characteristic cognitive biases:

1. Anchoring: when making a decision about something for which we have little or no information we tend to "anchor" that decision on information that we have derived from a related problem. In addition a characteristic adjustment is made because (of course) we know we are anchoring but experimental evidence consistently shows that such adjustments are inadequate, hence a bias is introduced.
2. Availability: to assess the risk of a particular state of the world we use examples already experienced. But the examples are unlikely to be representative instead they will be the most memorable. This availability and use of examples produces systematic biases in risk estimation. Such biases can be in either direction.
3. Representativeness: this rule of thumb is used when we assess the characteristics of a particular item or person A that belongs to a broader category B. We tend to use a stereotypical view of B and project it to A.

To complete this overly brief review of modern behavioural economics we can make reference to framing. Because of the three decision heuristics, or rules of thumb (and the resulting biases) decisions are inevitably framed in complex and uncertain conditions. This is based on the idea that individuals (inevitably) develop cognitive frames that guide perceptions, judgements and actions. These frames define the anchoring, availability and representativeness that make decisions possible. While guaranteeing an efficient use of experience, biases or prejudices are inevitable. The idea that decisions are framed has been developed after Penrose wrote TGF. But it appears that she was aware of the substantive issues involved. Consider the following:

> ... the creation of an 'optimum' plan for expansion requires that the resources available to a firm ... be used to 'best' advantage. It is obvious that if all necessary productive resources ... were available... at constant prices, and if demand for products were infinitely elastic, no 'best' plan could be constructed... (pp44-5)

The context of this quotation is that a management team provides an internal firm constraint. But, the use of parentheses with optimum and best suggest unhappiness with the terms even if an optimum can be defined in theory. This is consistent with a framing interpretation of the Penrose framework because frames imply that all solutions are local even if (in principle) a global solution is available. It is also consistent with complexity theory, introduced above, in which search is usually local rather than global. The relevance of this latter observation will become clear below.

To apply these ideas to Penrose's PO we must recognise that she populates firms with teams, and individuals exist as team members:

> Businessmen commonly refer to the managerial group as a 'team', and the use of this word implies that management in some sense works as a unit... [The] experience [managerial personnel] gain from working within the firm and with each other enables them to provide services that are uniquely valuable for the operations of the particular group with which they are associated. (p46)

Furthermore:

> The experience gained is not only of the kind ... which enables a collection of individuals to become a working unit, but also of a kind which develops an increasing knowledge of the possibilities for action and the ways in which action can be taken by the group itself, that is by the firm. This increase in

> knowledge not only causes the productive opportunity of a firm to change in ways unrelated to changes in the environment, but also contributes to the 'uniqueness' of the opportunity of each individual firm. (pp52-3).

In short, teams are collections of individuals based on common experience, learning and hence expectations of decision making and actions. In terms of earlier discussion, a cohesive team can be viewed as exploiting collective system one activity i.e. group behaviour that is uncontrolled, effortless, fast and unconscious in which control, effort etc are viewed in an organisational sense. In addition the team cognitive frame that develops generates common anchoring, availability and representativeness expectations and hence common and accepted cognitive biases. As such, cohesive teams are able to be efficient for exactly the same reason as system one activity is efficient and allows fast interpretation and decisions making in response to opportunities and threats. But, of course, a Penrose-type team can also generate new knowledge. Effective team generation of knowledge requires collective system two activity with attendant costs. Using observations from complexity theory this team system two activity requires high information variety but also high coherence and similarity to maintain collective learning and expectations. The possible implications here for PO functioning, recognising the costs of knowledge generation, will be explored shortly.

It is against this background that Penrose recognises the issues involved with new team members:

> Individuals with experience within a given group cannot be hired from outside the group, and it takes time for them to achieve the requisite experience. (p47)

This, of course, is the source of an endogenous constraint on firm growth. But it is also the source of additional issues that are relevant to understanding the functioning and significance of a firm's PO. One way of viewing this required learning and experience with new team members is the development of team network effects. As learning and experience develops this produces system one based administrative efficiency gains and hence a network effect based on increasingly common decision heuristics and team framing. As with all network effects, the attractor is absorbing and hence a locked-in solution i.e. a cohesive team based on common system one expectations is the end result of the development of common experience. This is not to suggest that a perfect team of this sort will evolve in practice for the same reasons

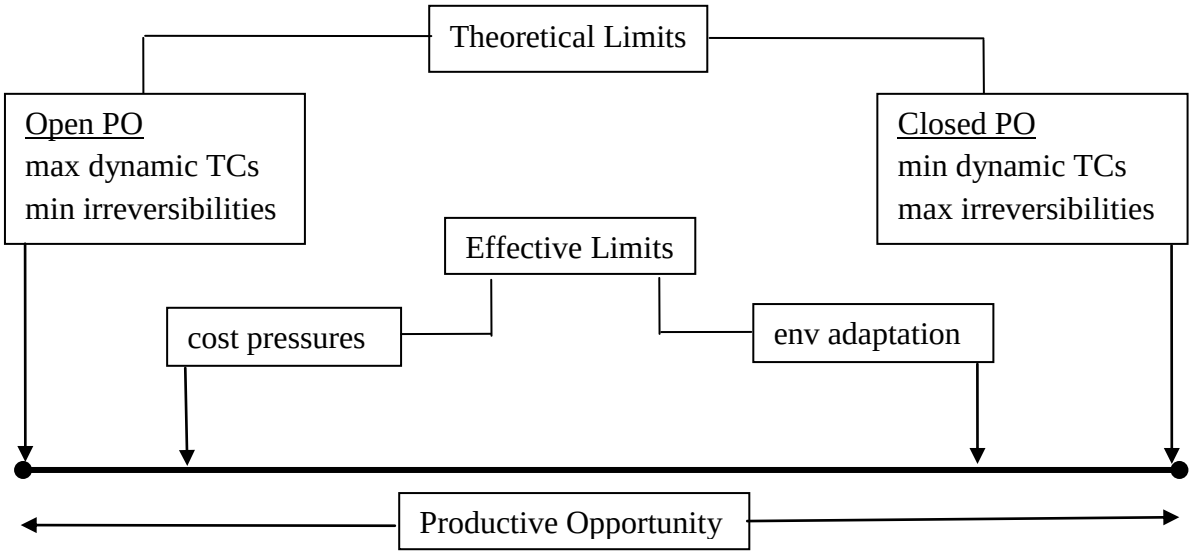
as the improbability of a fixed PO cited above. As well as environmental changes, staff turnover will generate a new learning and knowledge generation process resulting from variety generation. But recognising a locked-in attractor that develops with team learning and experience is a useful theoretical benchmark. A related, and important, issue here is that viewing team activity as a collective system one attractor generates an organisational irreversibility. The significance of this was highlighted above. The impact of the environment (in the last instance) requires an irreversibility of some type. Hence, collective system one behaviour also allows a long-run environmental impact on PO and firm behaviour a key aspect of Penrose's framework.

Using this logic we can think of two alternative POs. An efficient and static PO based on the dominance of collective system one behaviour. An appropriate name here is a closed PO. Complete closure is, of course, only a theoretical possibility because it requires a fixed PO with no new knowledge generation. But equally a team can incur costs of cognitive restructuring, with resulting new knowledge, as a strategic attempt to shift an absorbing team solution. In this case a team must be open to the development of new search activity resulting in new cognitive frames, hence we can refer to an open PO. The degree of openness is a strategic decision and depends on the extent to which a team can and is willing to incur the costs involved. These costs arise because team activity requires system two based decisions that involve managing information variety, coherence and cognitive distance. These costs are basically cognitive dynamic transaction costs, with the latter having the same meaning as suggested in Langlois (1992) and Langlois and Robertson (1995).

It is useful to think of open and closed POs as two ends of a spectrum with the extremes being theoretical limits rather than practical possibilities (see Figure 1). A completely closed PO has maximum irreversibilities and minimum dynamic transaction costs and hence is fixed. The fixity here implies that in a static sense the administrative structure has maximum efficiency because of the common team cognitive frame. But with environmental evolution, long-run viability implies a requirement to adapt to such developments. Hence an effective limit requires some minimum environmental adaptation with necessary expenditure on dynamic transaction costs. This is equivalent to Penrose's assertion (quoted earlier) that in the

final analysis the environment is a real constraint. The other extreme of the spectrum involves a fully open PO with minimum irreversibilities and maximum dynamic transaction costs. The objective here is restructuring of the team frame and hence involves maximum system two activity and costs. The latter cost pressures in the context of firm rivalry, implies an effective limit to the right of the theoretical limit. This is equivalent to a Penrose effect that places an internal constraint on firm development.

Figure 1: The PO Spectrum



It follows that long-run viable firms can position themselves between the two effective constraints in Figure 1. In principle this involves a set of possible firm PO positions that implies unique firms, a feature that Penrose emphasises in *TGF*. More precisely these are viable subjective POs because the positions of the effective limits are those expected by a firm. The extent of possible firm PO choice depends, of course, on the significance of competitive pressures (the left constraint) and environmental turbulence (the right constraint). In addition we can note that as other firms will also be responding to environmental developments these two constraints are not independent. The right hand constraint shifting left will lead to the left constraint shifting right if competitors successfully adapt to environmental developments. This shifting of the effective constraints will reduce the space that defines viable firm choices. The only situation in which firm uniqueness is not possible is if the two effective constraints meet in the centre of the spectrum, implying

only one viable PO. This implies extreme competitive pressures (to shift the left constraint) and major environmental turbulence (to shift the right constraint). This combination of possibilities produces an analysis that is not obviously consistent with a Penrose-type model.

For reasons that follow from earlier discussion an open PO can require openness in team membership (at least temporarily). In this respect we can distinguish small and large firms. Small firms can be defined in terms of a single management team. Large firms are made up of more than a single team. For a small firm new team membership requires temporary or permanent recruitment from outside. For a large firm, on the other hand, outside recruitment is less necessary e.g. a senior management team can intervene in a subordinate team. But new membership for a senior team follows the same logic as for a small firm.

POs and firm capabilities

This final substantive section further develops the themes set out above and in particular focuses on the understanding and conceptualisation of firm capabilities. A possible starting point here is to recognise the opinion expressed in TGF:

> Clearly no general theory of growth can take into account all of the particular circumstances of particular firms that will determine their ability to grow; but if there are environmental circumstances which affect in a systematic manner whole groups of firms the resources of which have some significant characteristics in common, then it is appropriate to analyse the prospects of growth for firms in such groups. In doing this we go further than we have gone so far in examining a relationship between certain specific characteristics of the resource-base of a firm and the firm's opportunities for expansion. (p217)

From this quotation it is clear that Penrose does not dismiss the possibility of environmental factors determining firm development, but her framework emphasises "the resource-base of the firm":

> There can be no question that for any particular firm the environment 'determines' its opportunities, for it must take its resources as given... [I]f we want to explain why different firms see the same environment differently, ... why the environment is different for every firm, we must take the 'resources approach'... (p217).

It is claims such as this that has led to a view that sees Penrose as one of the inspirations for a resource based perspective on the firm (for example Kor and Mahoney, 2000). While this is the case in a descriptive sense, if we restrict the connection to standard resource based theory in terms of analytical logic it is an incorrect linkage (Foss, 2002; Foss and Stieglitz, 2012).

The standard, or dominant, resource based approach to the firm (for example Barney 1986, 1991) is grounded in a Chicago approach to economics. This tradition is viewed as an alternative to the Structure-Conduct-Performance inspired Porter-type approach. The Chicago school emphasises ex-ante and ex-post limits to competition, imperfect resource mobility and firm heterogeneity (Foss 2002; Peteraf 1993). While this appears to be descriptively similar to Penrose's work, the equilibrium basis of the Chicago approach is not consistent with a Penrose-type logic.

But there is a second broad resource based tradition that is more consistent with TGF (Gavetti and Levinthal 2004; Foss and Stieglitz, 2012). This covers ideas of core competences (Prahalad and Hamel, 1994) capabilities (Denrell, Fang and Winter 2003) and dynamic capabilities (Teece, Pisano and Shuen, 1997; Teece 2007). The common element here is that a firm can alter its resource base; or using more Penrose inspired terminology: can alter the services derived from the resource base because of a changing PO. The dominant resource based perspective characteristically views the resource base as fixed. This broad capabilities tradition therefore emphasises learning, dynamics and evolution. In terms of the more recent contributions to economics considered above this requires team information variety but also coherence i.e. effective team based system two activity with attendant dynamic costs.

Teece at al (1997) emphasise the importance of rapidly changing environments. In addition they argue that learned collective activity allows a firm to improve performance. In Teece (2007) this is developed with an emphasis on successful organisations that sense opportunities. In terms of Figure 1 above, if a firm has relatively closed PO an increasingly dynamic environment will force a shift left along the spectrum. This shift will undermine existing team cognitive frames and force a greater use of system two rather than system one activity. Alternatively, if a firm already has a relatively open PO, existing cognitive frames can be used to exploit the

potential offered by a dynamic environment. This reiterates a point made earlier that system one based behaviour, and existing biases, may have an evolutionary advantage in terms of perception and adaptation. This connection between a cognitive base to PO functioning and dynamic capabilities is similar to Foss and Stieglitz's (2012) emphasis on the importance of cognitive representations of a firm's resource space and also the inputs from complexity theory introduced above. In addition the formulation suggested here, using modern economics, appears to offer a solution to the criticism of a lack of proper micro-foundations to the dynamic capabilities approach (Salvato, 2003; Felin and Foss, 2005).

One under-developed issue can be dealt with in the final part of this section. It has been suggested here that a firm's PO can be conceptualised in terms of inevitable team framing of decisions. But arguably in complex and uncertain conditions the same issue exists for consumers. Complex and uncertain conditions, i.e. turbulent demand-side conditions, undermine substantive consumer rationality. In terms of standard consumer theory, knowledge issues concerning future incomes and existing and future product prices and quality must be managed. This echoes Penrose's point that the environment is not an objective fact discoverable before the event, a feature that is as much an issue for consumers as well as producers. In this context consumer decisions are based on decision making heuristics involving anchoring, availability and experience, and representativeness as well as search and learning. The result is that the environment is inevitably an "image" for consumers as well as firms. This is particularly the case when decisions are irreversible, in the short-run, and hence non-replication cannot lead to learning and revision of frames. This is the consumer equivalent of knowledge based lock-in that was emphasised above.

A combined demand and supply-side framework is presented in Figure 2 in a rather schematic manner as a simple 2*2 matrix of possibilities. POs are identified as either closed or open. We need not repeat the detailed discussion that the theoretical limits in Figure 1 cannot exist in practice hence these PO categories should be viewed as relatively closed and open. A closed PO is (relatively) fixed and based (mainly) on system one team activity, whereas an open PO is more dynamic and based (mainly) on system two team activity with costly search and management of team coherence. The demand-side is analysed in terms of the turbulence of consumer decisions this

leads to categories in which decisions are either replicable or non-replicable. In the former case consumer learning is possible, because of (relatively) unchanged circumstances, along with revision of consumer cognitive frames, with the result that decisions are substantively rational in the long-run. With non-replicable decisions, because of the complexity and uncertainty of consumer decisions, learning in (relatively) unchanged circumstances is not possible, hence decisions are dominated by issues involving anchoring, availability and representativeness and hence cognitive bias.

Figure 2: The productive opportunity and consumer decisions

		Consumer decisions	
		Replicable	**Non-replicable**
Productive opportunity	**Closed**	Static competition Traditional RB theory	Uncertainty reduction Marketing effort.
	Open	Entrepreneurship Hayek	Dynamic competition-capabilities Penrose

The top left cell in Figure 2 is based on a fixed PO and long-run consumer rationality. The fixed PO implies a fixed firm resource base that is characteristic of traditional resource based (RB) approaches to the firm. The earlier discussed Chicago school grounding to this traditional approach has a comparative static logic. Hence this top left cell in the matrix is identified as static competition. In the bottom left cell, system two team activity becomes dominant but consumer decisions are still substantively rational in the long-run. This opens up short-run possibilities for entrepreneurial activity, because of the openness and short-run non-equilibrium decisions. This is consistent with the world identified by Hayek (1945) as entrepreneurship based on subjective knowledge that equilibriates markets.

The right hand column in Figure 2 is based on a non-replicable demand-side. This consumer complexity and uncertainty can either be based on macro conditions or firm radical innovation. The bottom right cell identifies these consumer circumstances with an open PO. This is the world specifically analysed by Penrose or more recently by

the dynamic capabilities approach to the firm. The top right cell is relevant for firms with a closed PO. This must be based on either macro based consumer turbulence and/or competitors producing the complexity-uncertainty. The latter is likely to be non-viable for a firm with a closed PO i.e. the environment is (in the last instance) a constraint here. For a viable firm, in this top right cell, the closed PO implies somewhat routinised innovation and change based on minimal team variety. As consumer decisions are based on rules of thumb this introduces the possibility of endogenising such decisions with marketing efforts. This is the world identified by Galbraith (1974) in which demand is endogenous to uncertainty reducing strategies of a firm's technostructure.

In short Figure 2 suggests that a Penrose type framework can be interpreted in two ways. First, it is a specific approach to the firm i.e. the bottom right cell in the matrix. Secondly, a developed Penrose-type analysis of a firm's PO can provide a meta-framework that can be used to locate different approaches to the analysis of the firm. This idea of a meta-framework for the analysis of the firm is based on Penrose's idea, clear from earlier used quotations, that no single approach to the firm is relevant in all circumstances. Instead particular approaches are required depending on the particular questions being asked and the resulting particular analytical methods that are adopted.

Conclusion

This paper has used ideas from modern behavioural economics and complexity theory to re-examined Penrose's idea of a firm's productive opportunity. The key input from behavioural economics is to recognise that in complex and uncertain conditions decisions are guided by cognitive frames that introduce cognitive bias. This inevitability of framing is viewed as a modern economic version of the environment inevitably being an "image", a feature emphasised in TGF. The use of complexity theory allows us to shift from individual to team decisions and introduce important issues involving change and knowledge creation. Any team can be analysed in terms of information variety (that is necessary for new knowledge generation) as well as coherence and similarity. This allows us to define a fixed PO as involving minimal team variety and high team coherence – this was termed a closed PO. An open PO was characterised as high variety (that is necessary for new knowledge), but a requirement for high coherence involved inevitable high dynamic transaction costs

that were interpreted as a cognitive based Penrose effect. In terms of behavioural economics a closed PO is based on the dominance of system one (automatic) behaviour whereas as open PO is dominated by system two (creative) thinking.

The ideas that linked framing and complexity to PO functioning allowed us to introduce a spectrum of PO types from open to closed. This spectrum then allowed us to introduce a long-run effect for the environment because of organisational irreversibilities as well as unique firm POs. This PO spectrum was then linked to demand side (consumer) framing of decisions. This combined supply-demand analysis could then be linked to four specific firm types one of which was a characteristically Penrose-type firm based on exploiting dynamic capabilities. In short, the discussion of Penrose's analysis of the firm undertaken here allows us to identify the Penrose firm as a particular type but also a Penrose-type logic that provides a meta-framework in which the firm has multiple meanings.

References

Antonelli C, Krafft J, and Quatraro, F (2010), "Recombinant Knowledge and Growth: The Case of ICTs", Structural Change and Economic Dynamics, 21(1), 50-69.

Barney JB (1986), "Strategic Factor Markets: expectations, luck and business strategy", Management Science, 32(10), 1231-41.

Barney JB (1991), "Firm Resources and Sustained Competitive Advantage", Journal of Management, 17(1), 99-120.

Beach LR (1993), Image Theory: Decision Making in Personal and Oragnizational Contexts, Chichester: Wiley.

Boulding KE (1956), The Image, Ann Arbor: Michigan University Press.

Cartwright E (2014), Behavioral Economics, London: Routledge, 2nd ed.

Coase R (1937), "The Nature of the Firm", Economica, 4(16), 386-405.

Coase R (1991), "The institutional structure of production", Nobel lecture, 9 December 1991, reproduced in O Williamson and S Masten (eds) (1995), Transaction Costs: Critical Writings, Aldershot: Edward Elgar.

Coase R (1993), "The nature of the firm: meaning", in O Williamson and S Winter (eds), The Nature of the Firm: Origins, Evolution and Development, Oxford: Oxford University Press.

Colombelli A., Krafft J, Quatraro F (2013), "Properties of knowledge base and firm survival: Evidence from a sample of French manufacturing firms", Technological Forecasting & Social Change, 80(8), 1469-1483.

Colombelli A., Krafft J, Quatraro F (2014), High Growth Firms and Technological Knowledge: Do gazelles follow exploration or exploitation strategies?, Industrial and Corporate Change, 23(1), 261-291.

Demsetz H (1983), "The Structure of Ownership and the Theory of the Firm", Journal of Law and Economics, 26(2), 375-390.

Denrell JC, Fang C and Winter SG (2003) , "The Economics of Strategic Opportunity", Strategic Management Journal, 24, 977-90.

Dietrich M (1994), Transaction Cost Economics and Beyond, London: Routledge.

Dietrich M and Krafft J (2011), "Firm development as an integrated process: with evidence from the General Motors-Fisher Body case", Journal of Evolutionary Economics, 21(4), 665-86.

Dietrich M and Krafft J (2012), "The economics and theory of the firm", in M Dietrich and J Krafft (eds), Handbook on the Economics and Theory of the Firm, Cheltenham: Edward Elgar.

Dosi G and Marengo L (1994), "Some elements of an evolutionary theory of organizational competences", in RW Englander (ed), Evolutionary Concepts in Contemporary Economics, Ann Arbor: The University of Michigan Press.

Felin T and Foss NJ (2005), "Strategic Organization: A Field in Search of Microfoundations", Strategic Organization, 3(4), 441-55.

Fleming L (2001), "Recombinant uncertainty in technological search", Management Science, 47(1), 117-132.

Foss NJ (2002), "Edith Penrose, Economics and Strategic Management", in C Pitelis (ed), The Growth of the Firm: The Legacy of Edith Penrose, Oxford: Oxford University Press.

Foss NJ and Stieglitz N (2012), "Modern resource-based theory(ies)", in M Dietrich and J Krafft (eds), Handbook on the Economics and Theory of the Firm, Cheltenham: Edward Elgar.

Fransman M (1994), "Information, knowledge, vision, and theories of the firm", Industrial ands Corporate Change, 3, 713-57.

Galbraith JK (1974), The New Industrial State, Harmondsworth: Penguin, 2nd ed.

Gavetti G and Levinthal DA (2004), "The Strategy Field from the Perspective of Management Science: Divergent Strands and Possible Integration", Management Science, 50(10), 1309-18.

Hayek FA (1945), "the use of knowledge in society", American Economic Review, 35(4), 519-30.

Kahneman D (2011), Thinking Fast and Slow, London: Penguin.

Kahnemann DP, Slovic P and Tversky A (eds) (1982), Judgement under uncertainty: heuristics and biases, Cambridge: Cambridge University Press.

Kor YY and Mahoney JT (2000), "Penrose's Resource-based Approach: The Process and Product of Research Creativity", Journal of Management Studies, 37(1), 109-39.

Krafft J, Quatraro F, and Saviotti P (2011), "The knowledge base evolution in biotechnology: A social network analysis", Economics of Innovation and New Technology, 20(5), 1-31.

Krafft J., Quatraro F, and Saviotti P (2014a), "The dynamics of knowledge-intensive sectors' knowledge base: Evidence from Biotechnology and Telecommunications", Industry and Innovation, 21(3), 215-242.

Krafft J., Quatraro F, and Saviotti P (2014b), "Knowledge characteristics and the dynamics of technological alliances in Pharmaceuticals: Empirical evidence from Europe, US and Japan", Journal of Evolutionary Economics, 24, 587-622.

Langlois RN (1992), "Transaction costs in real time", Industrial and Corporate Change, 1, 99-117.

Langlois RN and Robertson PL (1995), Firms, Markets and Economic Change, London: Routledge.

Loasby BJ (1991), Equilibrium and Evolution, Manchester: Manchester University Press.

Loasby BJ (2002), "The significance of Penrose's theory for the development of economics", in C Pitelis (ed), The Growth of the Firm: The Legacy of Edith Penrose, Oxford: Oxford University Press.

March JG and Simon HA (1958), Organizations, New York: Wiley.

March JG (1988), Decisions and Organizations, Oxford: Basil Blackwell.

Marengo L (1995), Structure, competence and learning in organizations, Wirtschaftspolitische Blatter, 6, 454-64.

Nightingale P (1998), "A cognitive model of innovation", Research Policy, 27(7), 689-710.

Nooteboom B (2012), "Cognitive theory of the firm: a pragmatist perspective", in M Dietrich and J Krafft (eds), Handbook on the Economics and Theory of the Firm, Edward Elgar: Cheltenham.

Penrose ET (1980/1959), The Theory of the Growth of the Firm, Oxford, Basil Blackwell, 2nd ed.

Peteraf MA (1993), "The Cornerstones of Competitive Advantage: A Resource-based View", Strategic Management Journal, 14(3), 179-91.

Prahalad CK and Hamel G (1994), Competing for the Future, Boston: Harvard University Press.

Ravix JT (2002), "Edith T. Penrose and Ronald H Coase on the nature of the firm and the nature of industry", in C Pitelis (ed), The Growth of the Firm: The Legacy of Edith Penrose, Oxford: Oxford University Press.

Salvato C (2003), "The Role of Micro-strategies in the Engineering of Firm Evolution", Journal of Management Studies, 40(1), 83-108.

Teece DJ, Pisano G and Shuen A (1997), "Dynamic Capabilities and Strategic Management", Strategic Management Journal, 18(7), 509-33.

Teece DJ (2007), "Explicating Dynamic Capabilities: The Nature and Microfoundations of (Sustainable) Enterprise Performance", Strategic Management Journal, 28(13), 1319-50.

Thaler RH and Sunstein CR (2009), Nudge, London: Penguin Books.

Weick K (1995), Sensemaking in Organizations, London: Sage.

Williamson O (1985), The Economic Institutions of Capitalism: Firms, Markets and Relational Contracting, New York: Free Press.