# *Complexity in international business: the implications for theory*

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**Complexity in international business: the implications for theory**

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ABSTRACT

International business is inherently complex for four main reasons: the large number of countries, products, technologies and firms involved; the intricate connectivity of international transport and communications networks, the diversity of the political, cultural and regulatory environment, and the speed and unpredictability of change. The complexity created by these features can be measured using the techniques presented in this paper. IB has developed simple and powerful theories which abstract from inessential details and thereby reduce the complexity of theory to a minimum. The assumptions underlying this theory are common to other disciplines, and provide a basis for future inter-disciplinary research.

100 words

## Complexity in international business: the implications for theory

### 1. INTRODUCTION

Prominent IB scholars have claimed that IB is a uniquely complex field of studies (Eden and Nielsen, 2020). Aguinis and Gabriel (2021), in their Point, assert, however, that such claims are exaggerated and misplaced. These claims, they suggest, have encouraged IB to become an intellectual silo cut off from other fields of management studies. The authors argue that IB is most productive when it has open and permeable boundaries that allow ideas to be imported from and exported to related disciplines. Believing IB to be uniquely complex impedes this movement of ideas.

This critique of Aguinis and Gabriel (2021) suggests that their criticisms are misplaced. IB is indeed a uniquely complex subject and it is so for good reasons. The real-world complexity of IB studies arises from the heterogeneity of the key units of analysis, namely the nation and the firm, the intricacy of the spatial networks by which they are connected, and the sustained and rapid evolution of the global business system. Furthermore the spatial networks in IB are of different kinds - knowledge transfer, product flow and management coordination - each of which has a different configuration.

Despite this real-world complexity, IB studies has been rendered simple and straightforward by the power and simplicity of the theoretical principles that it employs (Buckley and Casson, 2001). IB theory has developed simple models, in which over 150 different countries, tens of thousands of firms and millions of different products are reduced to very small numbers of representative units, e.g. two rival firms, two countries and perhaps just a single product. Likewise, IB theory summarises the technical details of complex production systems using simple economic indicators such as profit-margins and unit costs.

IB theory is subtle and sophisticated. It abstracts from all the detail that does not really matter for the analysis of any given issue, and pares the analysis down to highlight key relations between critical factors. Many of the principles that underlie IB theory can be applied in other disciplines too. This creates a bridge between IB and other disciplines which can be readily exploited. Aguinis and Gabriel (2021) have under-estimated the salience of this point.

If IB is becoming a silo, as the previous authors suggest, it is for very different reasons. IB has striven to differentiate itself from related fields of study, e.g. strategic management and international marketing, in order to defend the autonomy of IB studies within the business school, and protect the jobs that go with it. Furthermore, IB has developed a series of silos within itself, which correspond to the different tracks that routinely dominate its annual conferences. These sub-silos encourage IB researchers to specialise in narrow topic areas, leading some scholars to lose sight of the general principles that give their subject such vitality. Although the previous authors are right to argue that IB benefits from permeable boundaries, their premises are wrong. It is not some misguided belief in the complexity of the subject that discourages links with other subjects, but rather a mind-set generated by the pressures of academic survival in the modern business school.

The ability of IB theory to simplify complex problems, as highlighted above, is a major intellectual selling point (Verbeke, van Tulder, Rose and Wei, 2020). Sustained development and formalisation of this theory will maintain, and indeed enhance, the wider reputation of IB studies. Contrary to what the previous authors suggest, IB scholars do not suffer from 'false uniqueness bias'; to promote their subject more widely, they simply need to capitalise on the strengths of IB theory, and develop its wider potential.

This counterpoint is structured as follows. Section 2 begins by exploring the concept of 'complexity'; different aspects are distinguished and then examined in turn. Section 3 identifies the key dimensions in IB analysis and shows that each dimension can be examined at different levels of aggregation. Section 4 illustrates how complexity is generated through classification and cross-classification applied to the various dimensions identified in section 3. Section 5 examines the networks of relationships which are such a prominent feature of IB activities. Section 6 examines the dynamics of the IB system, and the complexity that is involved in analysing process and change. Various numerical measures of complexity are introduced at each stage. Section 7 contrasts the complexity of the subject with the simplicity of the theory. This simplicity arises from the straightforward nature of the key principles on which the theory is based, and gives the theory considerable versatility. Section

8 concludes by arguing that IB studies needs to build on its strengths, and avoid excessive self-criticism.

## 2. ALTERNATIVE CONCEPTS OF COMPLEXITY

### 2.1. A brief review of the literature

The concept of complexity is rarely defined, and Aguinis and Gabriel (2021) is no exception. It is generally accepted that there is no agreed definition. Complexity can, however, be regarded as the opposite of simplicity; this suggests that a complex system involves an intricate pattern of relationships between different objects that is difficult to understand.

The literature on complexity covers a wide range of topics (Manson, 2001). The modern literature was initiated by Simon (1964); he describes a complex system as possessing many parts that interact in a non-simple way, but unfortunately he focuses mainly on hierarchies. Fortunately a number of important recent papers in IB have contributed to the analysis of complexity (e.g. Vahlne and Johanson, 2021). Five papers are particularly relevant to this counterpoint and are discussed below.

Asmussen, Benito and Petersen (2009) have examined complexity in the market entry decision. They distinguish between foreseeable and observable contingencies ('ordinary contingencies'), such as product and place, and unforeseeable or unobservable contingences ('meta-contingencies'), such as customer reactions and competitive responses. These contingencies must be considered when making an entry decision, Successful entry, they argue, depends crucially on the managerial capability to handle meta-contingencies, e.g. the ability to learn from experience and improvise solutions to unforeseen problems such as consumer reactions and competitive responses by other firms.

Hashai and Adler (2021) analyse in depth competitive response as a source of complexity. They interact competitive complexity with the complexity created by long and intricate supply chains, and show how competition between rival supply chains can be analysed in terms of the theory of games. Although a realistic model would be detailed and difficult to solve, a simple model can provide insight and intuition that will improve decision-making by managers engaged in supply chain competition.

Bekes, Benito, Castellani and Murakozy (2021) develop this approach using the concept of a business 'footprint'. Their focus, however, is on the complexity of the operations controlled by the management of the firm rather than the complexity of the environment in which the firm operates. They distinguish between the 'extent' and 'boldness' of the footprint. The extent of the footprint reflects the range and locations of the activities in which the firm is involved, whilst its boldness of the footprint reflects the level of risk that it incurs. The complexity of the firm and the complexity of the environment may be related, however. It could be said that the extent of the footprint reflects the ordinary contingencies described above, while the boldness of the footprint reflects the meta-contingencies. It is possible, though by no means certain, that complexity of the environment could stimulate not only complexity in decision-making but also complexity in the footprint of the firm.

Other IB scholars have approached the issue of complexity from a psychological rather than an economic perspective. Caligiuri, de Cieri, Minbaeva, Verbeke and Zimmermann (2020), for example, examine the managerial complexity created by the COVID crisis. Interruptions of supplies arising from staff illness, social distancing requirements and export bans have caused managerial expectations based on a state of normality to be suddenly falsified, creating stress, anxiety and confusion. Complexity increases because of the range of different scenarios that have to be considered in every decision. This provides a new and insightful contribution to the analysis of risk and complexity summarised above.

Finally, Aguinis, Rawani and Cascio (2020) examine complexity in the research process itself. They report that the mismatch between theoretical constructs and evidence on actual behaviour generates complexity for researchers attempting to reconcile theory with practice. This is particularly acute when analysing managerial responses to risk, as discussed above.

2.2. Different types of complexity

To position the current debate within the wider literature it is useful to make three key distinctions.

The first is between the complexity of *reality* itself, which is enormous, and the complexity of a *theory*, or model, that is used to analyse reality, which is necessarily much lower. The focus of this paper is on the complexity of theory, although the complexity of reality is considered too.

The second is between complexity of *structure* and 'complexity of *process*. Structure refers to the range and diversity of the elements in a system and the 'tapestry' of the connections between them. Process, on the other hand, refers to the behaviour of the system over time, as determined by the decisions of autonomous agents operating within the system as they respond to external changes. This paper focuses on structural complexity, which is the main topic of the current debate, although issues of process are briefly discussed as well. The debate over structural complexity in the previous papers is particularly interesting because there until recently there was little discussion of this subject in the management literature as a whole.

The third distinction is specific to applications in business and management studies. It is between the complexity of the *environment* to which managers react, or seek to control, and the complexity of the *management structures* they create for this purpose (Contini, 2017). Most management scholars advocate simple but versatile structures for managing complex environments, but others advocate stable complex structures that micromanage the environment instead. The focus of this paper is on the complexity of a firm's environment, although the discussion has implications for the complexity of management structures too.

2.3. Real-world complexity and theory complexity

It is useful to examine the first two distinctions more closely.

As indicated above, real-world complexity refers to the complexity of the reality that is being studied, while theoretical complexity refers the complexity of the representation of the same reality afforded by a theory or model. Real-world complexity cannot be assessed directly. For example, real-world business activity is embedded in an intricate socio-economic system that cannot be observed under controlled experimental conditions. Unlike a scientific laboratory experiment, the system is not under anyone's complete control, The only thing that is completely controlled is the choice of the theory or model that is used to interpret the behaviour of the system.

An investigator of a complex real-world system therefore has two main options. One is to focus on some small subset of the real-world system that is sufficiently simple that it is easy to describe in detail. The other is to construct a theory or model of the entire system by abstracting from superfluous detail, as indicated above. What is deemed superfluous will depend on the research question. Different investigators, asking different questions, will therefore make different simplifying assumptions. These assumptions necessarily involve some element of professional judgment; they can only be assessed in retrospect, when the predictions made using alternative sets of assumptions are compared with actual outcomes.

The more complex the real-world problem that needs to be studied, the more complex the corresponding theory or model is likely to be. But the more complex the theory, the more difficult it is to understand; and the more difficult it is to understand, the more difficult it is to teach. IB studies deals with real-world problems of exceptional complexity, which need to be understood by people from very different backgrounds. IB scholars have therefore invested heavily in developing theory that is both directly relevant to real-world situations yet easy to understand and teach.

### 2.4. Structural complexity and process complexity

The contention of this paper is that structural complexity is extremely high in IB studies because of the many different nations, firms and industries involved and the many connections between them.

It can also be argued that process complexity is high as well, because of the uncertainties associated with technological innovation, political and social changes oligopolistic rivalries, etc. It must be conceded, however, that the difference between IB and other subjects is not so great in respect of process as in respect of structure. Financial markets, for example, regularly trade complex claims whose value is contingent on a range of uncertain future events (Brock and Hommes, 1997). For this reason the emphasis of this paper is on structural rather than process complexity.

There is an enormous management literature on process complexity (Vahlne and Johanson, 2021).

It is often discussed under the rubric of 'computational complexity' although this term is given multiple interpretations in the literature. In a real-world context it may refer to the practical problems of decision-making under uncertainty, and in particular the difficulty of optimising some performance measure in a volatile and unpredictable environment (Aksentijevic and Gibson, 2012). In theoretical terms it may refer to the additional complexity introduced into a model by a volatile environment, multiple decision-makers, multi-period decision-making, and subjective probabilities (Chellappan, Gupta, and Venkat, 2021). In computer science theoretical process complexity is often referred to as 'computational complexity', and relates to the time taken by an algorithm to solve a mathematical problem. Unfortunately this term has recently been applied in various branches of management studies in a way that is inconsistent with this original use (Bossaerts and Murawski, 2017).

## 2.5. The classification and measurement of theoretical complexity

Aguinis and Gabriel (2021) provide a classification of complexity. This is implicitly a classification of theoretical complexity, although they do not make this explicit. They follow Eden and Nielsen (2020) in recognising three distinct dimensions of complexity: multiplicity, multiplexity and dynamism. Multiplicity and multiplexity represent different aspect of structural complexity, whereas dynamic complexity, as its name suggests, is mainly concerned with process complexity.

Multiplicity corresponds, broadly speaking, to the heterogeneity of the basic elements in the structure; it can also be described as categorical complexity, i.e. the complexity created by the existence of many different types of entity, each of which belongs to a different category.

Multiplexity refer mainly to network structures, which were also mentioned above; multiplexity is particularly high if the connections between the elements involve different types of flow which may go in one direction or another, or in both directions at once.  Dynamism refers to change over time.

Dynamism is exemplified by sequential exogenous shocks which disturb a system. When actors in the system plan ahead dynamism complicates decision-making, especially when there is uncertainty about the future, and decision-makers base their judgements on subjective probabilities.

This paper develops this approach further. It introduces metrics that can be used to assess the various dimensions of complexity (Rebout, Lone, De Marco, Cozzolino, Lemasson, and Thierry, 2021). Real-world complexity cannot be measured directly, as indicated above, because everything observed is based on appearance. However, an approximation to real-world complexity may be achieved by allowing the dimensions of a theoretical model to increase, to match the complexity that an ordinary observer of the system would perceive.

This paper suggests eight different measures of complexity. They are referred to as dimensionality, classification, cross-classification, assortment, connectivity, partition, volatility and persistence. The first three represent different aspects of multiplicity, the next three different aspects of multiplexity, while the last two represent different aspects of dynamism. These three aspects of complexity are examined in turn in the sections below. A practical illustration of the application of some of these measures is given in the Appendix.

## 3. STRUCTURAL COMPLEXITY: DIMENSIONS OF ANALYSIS

One reason why IB studies is so complex compared to other disciplines is that it embraces no less than four different dimensions of analysis: production, location, ownership and management (Vasconcelos and Ramirez, 2011). By comparison, other subjects often focus on just one or two dimensions, e.g. mainstream economics is mainly concerned with production, geography with location, finance with ownership and organisational studies with management.

### *Production*

The most familiar unit of analysis in IB is the firm. In economics the firm is the basic unit of production at the micro-level . Most economic theories of the firm, however, regard it as a 'black box'. But IB theory opens up the black box to look inside. It identifies a network of plants, e.g. factories, warehouses, shops, research laboratories, and headquarters offices. These 'black boxes' can in turn be opened up; inside each may be found teams of employees, and inside each team is found the individual team member or worker. This is generally the smallest unit of analysis found in IB; it may be referred to as the pico-level. Below this level, other disciplines normally take over.

The unit of analysis can also be raised; firms can be merged into industries (meso-level), and industries aggregated into production as a whole (macro-level).

*Location*

It is the nature of IB studies that space is important. The fundamental role of space is one reason why IB studies tends to be more complex than other disciplines, many of which do not take space so seriously.

The largest spatial unit of analysis in IB studies is the global economy as a whole. The initial step in the subdivision of space identifies the major continents, free trade areas, trading blocs, and major concentrations of economic power, such as the 'Triad' countries. Next below are individual nation states. These are the basic meso-level entities that are, by definition, the focus of IB theory. Nations determine the laws governing business conduct, rates of taxation and subsidy, and the tariffs or non-tariff barriers imposed on trade.

Nations may be further sub-divided into provinces, countries, or, in the case of the US, individual states. Below this level are the major cities and conurbations. The process of subdivision can be continued, using, for example, the successive lines of a postal address, to distinguish the street, the premises, and even an individual room in an apartment block.

The finest subdivision is effected by coordinates of longitude and latitude, which uniquely identify each point on the surface of the Earth. In conjunction with a map, these coordinates provide useful economic indicators, such as distance to any other point by a direct route; also soil fertility, climate, proximity to a river or the coast, and other useful information.

*Ownership*

Ownership in IB generally relates to ultimate corporate ownership, as indicated by the country in which the parent firm is legally headquartered. The interaction of plant location with plant ownership generates numerous possible combinations, as described below.

Internalisation by an MNE simplifies the ownership structures involved in IB because it eliminates more complex structures involving licensees, franchisees, subcontractors and joint venture partners. This is particularly important where lengthy supply chains are involved, where out-sourcing diffuses control and replaces management authority with potentially complicated negotiation (Huang, Han and Macbeth, 2020; Wiedmer, Rogers, Polyviou, Mena and Chae, 2021)

*Management*

Within an MNE the corporate management team is normally divided between headquarters and individual subsidiaries. A hierarchical management structure can be represented by a decision tree. Each vertical line in the tree represents a line of authority, e.g. from supervisor to supervisee. The seniority of a manager is indicated by their level in the tree. At any given level of the tree, different managers will typically perform different roles, i.e. they may be responsible for different functions, different products, or different market areas. Roles may also differ between successive levels of the tree.

In 'flat' organisations many decisions are made by committees and many strategies are implemented by teams. Most committees have chairs, however, and teams have leaders, so a hierarchical tree may still be appropriate. Each team leader may control  several supervisees, and each chairperson may preside over several committee members. A person's seniority may not reflect their level in the tree; indeed highly skilled team members near the bottom of tree may earn more than senior people higher up the tree.

## 4. STRUCTURAL COMPLEXITY: MULTIPLICITY

### 4.1. Simple classification

Classification refers to the number of different types of units found in each dimension of analysis. With no classification, all units are implicitly regarded as the same. This approach is often applied to firms in simple economic models of a competitive industry. Classification implies heterogeneity, the degree of which is reflected in the number of categories used. The finest classification accords each unit its own identity, and gives it a name. IB case studies exemplifies this, where leading firms in an industry are identified by name and discussed separately. Most classifications represent an intermediate case where there are several different categories and several units are allocated to each category.

*Production*

Products can be classified in various ways. Intended use is the most common criterion, e.g. cosmetics such as hair spray and face cream. The technology used to make a product work is another, e.g., radio, electric light. Others are classified by the materials from which they are made, e.g. metalwork, while food and drink are often described by their ingredients, e.g. beef and bacon. All of these criteria are used in standard industrial classifications, some of which are defined up to an eight-digit level. Products can also be classified by stage of production, e.g. raw materials, intermediate products and final products.

*Location and ownership*

Plant location and ownership are normally both classified by country. There are approximately 200 countries in the world, of which about 30 are significant foreign investors.

*Management*

Management is usually classified by structure, and structures are often identified using contrasting ideal types, e.g. centralised (*U*-form) or decentralised (*M*-form); high trust (*X*-form) or low-trust (*Y*-form); formal or informal (*Z*-form); flexible or inflexible (e.g. project-based) and so on. In IB theory a distinction is also drawn between autonomous and dependent subsidiaries (Williamson, 1985; Ouchi, 1981).

4.2. Cross classification

Cross-classification arises when two or more dimensions of a classification are combined. If there are $M_1$ categories in one dimension and $M_2$ in another then when both dimensions are employed there are $M_1M_2$ categories. As additional dimensions are added the number of categories increases at an accelerating rate. With $N$ dimensions there are $M_1M_2\ldots.. M_N$ categories altogether.

IB cross-classifications include

- production with location (different types of product are produced in different locations);
- ownership with location (firms headquartered in different countries own plants located in different countries);
- management and location (subsidiaries in different countries adapt their management styles to local conditions);
- ownership and product (firms headquartered in different countries produce different types of product);
- ownership and management (firms that are owned in certain countries adopt specific styles of management); and
- management and product (the production of different types of product is managed in different ways)

Three-way and four-way classifications are also used, e.g. early post-war US MNEs were said to produce high-technology products in developed European countries using formal hierarchical models of management, while UK MNEs produced food and minerals in developing countries using relatively informal and personal models of management. A simple numerical example of the generation of complexity through cross-classification is set out in the appendix.

### 4.3. Assortment

In practical applications of a classification scheme each unit in a sample or population is usually allocated to a one particular category. If the are $N$ units, each of which has its own identity, and $M$ categories, then there are $M^N$ different possible assortments. This applies whether the categories are generated by simple classification or by cross-classification.

## 5. STRUCTURAL COMPLEXITY: MULTIPLEXITY

### 5.1. Connectivity

Consider a set of units that are all of the same type, but each has a separate identity, e.g. firms or individuals. These units may be connected. Thus the owners or managers of two separate firm in a given industry might know and trust each other. Let there be $N$ firms in the industry; then there would be $V = N(N - 1)/2$ different possible connections of this type. Each connection could, in principle, exist independently of the others. There are therefore $T = 2^V$ different possible configurations of the network. Let the number of actual connections be $C$. Overall connectivity may be measured by $C/V$. The greater the connectivity, the greater the opportunities for co-operation in the industry. This could benefit customers through co-investment in worker education or shared infrastructure, or damage their interests through collusion over price.

Let the managers be indexed $i = 1.,,, N$. Let manager $i$ have $c_i$ connections to other managers, where $\sum c_i = C$. Then $c_i /V$ is a measure of the influence of manager $i$ within the network; while $c_i /C$ measures the extent to which their power dominates that of others.

Connections can also be used to analyse marketing strategies. Consider for example a set of $K$ major customers, each of which can communicate with one or more firms. There are $KN$ possible configurations of the network linking customers and firms. The more customers a firm can connect with, the greater its sales potential. The more firms a given customer can connect with, the greater their bargaining power. The most profitable firms will tend to be the firms that have the most connections with those customers who do not have many connections with other firms as well.

A similar analysis can be applied to the influence of directors on the policies of firms they serve. Different firms may have different numbers on directors on their board. The more directors there are on the board, the smaller the influence of any given director and the greater the power of management (as the board is less likely to be able to agree on strategy); conversely, the fewer the directors, the greater the influence of each director on corporate strategy and the weaker the influence of management. The most influential directors are those that serve on the greatest number of boards that have a small number of directors. This analysis is relevant to the issues of secret trusts, which acquire substantial interests in competing firms, place nominees on their boards, and then promote collusion through their nominees.

Connectivity between managers and between firms raises many important issues in IB. The topic is particularly suitable for historical research, as many connections of this type are highly confidential.

5.2. Partitions

Partitions are a major source of complexity in any system. They are relevant to industrial concentration, to firm-specific advantage, and to resource-based theories of the firm, but do not often appear in IB theory. Their potential relevance to IB theory is illustrated by the example below.

Consider a global population comprising *N* managers, each of whom works as part of a team. Each team manages a single firm within a given global industry. A team can involve any subset of managers up to size *N* (by convention an owner-managed firm has a management team of size one). Managers can be teamed up in many different ways, although each manager can belong to only one team. Some combinations of managers work well together, and others do not.

The theory of partitions shows that there are $S(N)$ possible configurations of teams, where *S* is the Stirling number of the second kind (Merca, 2014). This describes the number of ways in which a set of *N* different managers can be partitioned into a set of teams. The Stirling number accelerates rapidly with respect to *N*; thus $S(4) = 15$, $S(5) = 52$, $S(6) = 203$, $S(7) = 877$, and so on.

Suppose that each team develops and exploits a specific type of product, and that the profit it makes is independent of the profits made by other teams. (At this stage profit is measured gross of management salary costs, which are later subtracted to determine net profit.) A given partition of the set of managers generates a unique set of firms in the industry. The profits generated by each active firm can be summed to generate the total profit of the industry.

Economic efficiency of the industry normally requires the maximisation of total industry profit, subject to the constraints on the supply of managers as described above. The owners of each firm compete to recruit their preferred combinations of managers. Competition between the firms increases management salaries up the point where some firms drop out of the bidding because their salary bill exhausts their gross profit. Eventually an equilibrium is reached in which (1) each manager receives the best offer they can expect to get, (2) all the firms that operate break even or make a profit, and (3) the remaining firms cannot operate because they cannot recruit all the managers they require without incurring a loss.

In equilibrium each manager receives a salary just slightly above the salary that they would have received if they had accepted the best alternative offer. Bidding stops when equilibrium salaries have been offered and accepted by the managers. The surviving firms all break even or make a small net profit. This determines the optimal configuration of firms, the remuneration of each manager, and the profits of each active firms.

The theory shows how the firm with best combination of managers makes the highest profit. The industry will normally generate a wide variety of products. Each firm will produce a different product because it will employ a team of managers with a distinctive mix of skills. . The firms with the largest teams are on average likely to make the largest profits, but this is by no means assured. A small firm with a highly individualistic entrepreneur has the potential to make a large profit too.

It is possibly to proxy the size of firm by the number of mangers employed. Given this measure, it is easy to measure industrial concentration by the Gini coefficient, or the Herfindahl index, or some other statistic (Naldi and Flamini, 2016). It is possible to measure the distribution of profit across the firms in the same way too. Note, that is not appropriate to use these indices as measures of monopoly power in the industry. By assumption each team produces a non-competitive differentiated product; each firm has a monopoly of its own specific product, but not necessarily a large share of total sales and employment in the industry.

## 6. PROCESS COMPLEXITY: DECISION-MAKING IN A DYNAMIC ENVIRONMENT

Classic IB theory has been criticised in the past for being too static. The theory needs to be made more ‘dynamic’, it is said (Colli, 2015; Pitelis and Verbeke, 2007). But dynamic theories are inherently more complicated that static theories, which is why many theorists do their best to avoid them. Dynamics are intimately associated with process: the more complex the process, the more difficult it becomes to analyse its dynamics. For the purposes of this paper, therefore, it is reasonable to equate the dynamics complexity of Eden and Nielsen with process complexity, as defined above. There are many different aspects of process complexity; some are easy to measure, but some are not.

Most dynamic theories involve a periodisation of time. It might be suggested that the number of periods is a convenient measure of process complexity. But there is a problem. Whilst empirical studies of dynamic phenomena are necessarily confined to finite periods of time, most dynamic theories cover a potentially infinite period; indeed many relate to continuous time. The period of time does not therefore differentiate adequately between different degrees of process complexity.

Dynamic theories are often concerned with uncertainty about the future. The more volatile the environment, the greater this uncertainty, other things being equal. However, if it is easy for decision-makers to reverse their decisions, then volatility has limited impact. What happens in each period is largely determined by events in that period and not by the legacy of the past. The timeline of events is just a snapshot of a series of unconnected actions.

The decision problem becomes serious when the environment is volatile but decisions cannot be easily reversed; in other words, when the environment is unpredictable from period to period but the decision-maker is locked into any decision that they make. A combination of volatility in the environment and persistence (i.e. lack of volatility) in response creates complexity for the decision-maker that is so serious that it needs to be analysed by a dynamic theory.

Dynamic theories become particularly complex when structural complexity (as previously described) and process complexity (as described here) interact. Structural complexity means that there are a large number of independent decision-makers making a large number of related decisions (e.g. different firms making different market entry decisions), while process complexity means that each of these decisions involves a substantive long-term commitment whose outcome depends on an uncertain environment and on the decisions made by other decision-makers too.

While it is more difficult to measure complexity in a dynamic theory than in a static theory, there are certain types of dynamic theory for which it is relatively easy to construct complexity measures. For example, the complexity of a dynamic theory involving strategic interactions can often be measured using the dimensions of a decision tree. Consider, for example, the evolution of a global industry. The industry begins in an oligopolistic equilibrium, which is then disturbed by an innovative potential entrant. This threatens the incumbents (who may once have been innovators themselves). If the incumbents anticipate entry by the innovator, they may move first to pre-empt it, e.g. by tying in existing customers with loyalty schemes, or buying up key resources that the entrant is likely to require. A smart entrant will therefore disguise their plans to gain an element of surprise. With first-mover advantage they may be able to anticipate how the incumbents will respond to entry, and foreclose their options by strategies of their own. For example, they may enter on a large scale rather than a small scale, driving down marginal costs, so that they are bound to win a price war; the incumbents must therefore either agree to share the market with them or quit it altogether.

This sequence of moves and countermoves can be represented by a tree in which new branches develop with each successive move (Casson, 2016). In the scenario above, the incumbents have the option of moving first, the entrant moves second, the incumbents respond, and the process alternates until all the participants have committed all of their available resources. Once it has been specified who believes what about whom at each stage of the process, the decision tree can be used to predict the outcome,. In most cases the sequence of moves is crucial to the outcome.

The complexity of the strategic process can be measured by the number of roots at the bottom (final stage) of the tree. Let $S$ be the number of stages, and $R$ the average number of branches at each stage; then complexity, $C$, is approximately equal to $R^S$.

## 7. THE ROLE OF IB THEORY: RADICAL SIMPLIFICATION OF A COMPLEX REAL-WORLD SYSTEM

Several of the contributors to complexity theory in IB have been theorists, and amongst these theorists there are several who can be described as 'modellers' who have employed mathematical techniques (graphical or algebraic) to analyse IB issues. It is easy to see why modellers would be interested in complexity. As explained in this paper, many theorists have been struck by the complexity of the IB system. Indeed, part of the attraction of IB studies lies in the challenge of radically simplifying the representation of a highly complex system in order to make it more intelligible. Critics of IB theory, on the other hand, often question the assumptions on which these models are built.

Simplifying a complex system using a formal model is a distinctive research skill. Most theorists have a specific object in view – a research problem that they need to resolve – and they construct their model by eliminating all the extraneous detail that might distract from the problem. Strong assumptions are often made for this purpose; these assumptions do not represent a dismissal of extraneous factors, but rather a recognition by the modeller that these extraneous factors are so important that they require a different type of model to analyse them.

IB modellers are typically interested in the IB system as a whole, rather than the individual firms – i.e. the MNEs themselves. This explains the focus of the complexity literature on the system rather than the firm. The analysis of complexity in this paper has demonstrated the importance of the skill of the modeller in analysing the IB system as a whole. A modeller can take a general model of the system, such as one of those described above, and reduce the dimensions of the analysis so that intuition can be used to interpret the model. For example, a complex model containing $H$ firms operating in $N$ countries, can be reduced a simple model involving just two firms and two countries. This simple model will illustrate vividly most of the effects that could be observed within the larger and more realistic model.

As explained above, there is both a structural and a process dimension to IB theory. If process can be simplified in the same way that structure was simplified in the example above then a simple dynamic model of the IB system can be developed. Various ways of simplifying the dynamics have been noted. One of the most effective – and popular - methods is to use game theory to analyse the interactions between oligopolistic MNEs in an innovative industry. Some modellers have used simultaneous decisions games, while those who are most committed to the dynamic approach use sequential games (Casson, 2016; Hashai and Adler, 2021).

The skills of IB modellers, it may be suggested, are a significant asset to the IB profession. Yet the IB profession, it can be argued, has not exploited these skills as fully as it might have done. In the light of recent political turbulence, the trend to de-globalisation, and the COVID crisis, there is an increasing demand for a more dynamic approach to the IB system (Verbeke and Yuan, 2020). The dynamics would encompass the interplay of business and politics, as well as rivalry and cooperation between firms. It is hoped that the analysis of complexity presented here will promote the wider use of formal modelling, with its emphasis on the simplification of complex systems, and result in a new suite of models that will address the wide set of issues with which IB scholars now need to engage.

A new emphasis on simple formal models will also build bridges to other disciplines as advocated by Aguinis and Gabriel (2021). The formal analysis of location factors will reinforce existing links with economic geography; the formal analysis of knowledge generation will facilitate closer integration with innovation studies; while the formal analysis of coordination through internal markets will build closer links to institutional theory and management science. New linkages can be established too. To analyse environmental change, for example, IB can extend its analysis of supply chains to include recycling, and waste management in general, e.g. the present 'linear model' of supply chains can be extended to embrace emerging models of the 'circular economy'.

## 8. CONCLUSIONS AND IMPLICATIONS FOR FUTURE RESEARCH

This paper has shown that complexity is itself a complex subject. The concept has never been properly defined, and the different forms of complexity have not been so clearly distinguished as they should have been. Under these circumstances it is not surprising that controversies should arise over the complexities of different subjects. This paper has shown that the claims of Eden and Nielsen are correct: IB studies is indeed a uniquely complex subject. The logical structure of IB theory is simple and straight-forward however. The key principles can be understood from an analysis of two firms competing in a two-country world, but, if desired, the model can be scaled up to many countries, many firms, and, indeed, many different varieties of product too.

Other management disciplines possess some degree of complexity too, but few, if any, can rival that of IB studies. Aguinis and Gabriel (2021) argue that IB studies is no more complex than entrepreneurship, strategy and organisation studies. But IB theory already embraces significant elements of theory from each of these fields. Not only does it synthesise theory from different fields of management studies, but it adds an international dimension too. This significantly increases the amount of cross-classification involved. IB theory recognises that every worker, every manager, every plant and every firm is located in space, and possesses unique coordinates that define its position. Workers interact within the plant, plants interact within the firm, and firms interact with each other, and with politicians and other stakeholders too. These spatial interactions create massively complex webs of communication and orchestrated movements, whose general structure theory is able to explain.

The power of IB theory to engage with complexity in a manageable way is a profession-specific advantage (or PSA). The profession has become multinational; it is represented everywhere where IB-trained professionals practice their skills. The profession has become an integral part of the phenomena it studies.

The profession needs to leverage its PSA in much the same way as an MNE would leverage an firm-specific advantage (or FSA). It should enter emerging fields of study (new 'markets' for professional study) and exploit its unique ability to interpret highly complex phenomena in a direct and intuitively simple way. It should move first, before other disciplines colonise IB territory instead. The only thing that may be lacking is the confidence to do this. Aguinis and Gabriel (2021) undermine this confidence by accusing the profession of false uniqueness bias. A close examination of this claim, however, does not support it. This paper has suggested that, on the contrary, the profession should have the confidence to rise to the challenge and take advantage of new opportunities. An exciting research agenda awaits; IB scholars 'have the tools', so they just need to 'get on with the job'.

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**Appendix: Case study of the measurement of structural complexity in a simple IB model**

The complexity of IB studies and the power of IB theory may be illustrated by a simple example. Consider a world composed of $N$ different countries, populated with $H$ firms, all of which are potential MNEs. Each firm uses a different proprietary technology to the others, although consumers regard their final products as basically the same. It is desired to determine which firms supply which markets, what prices will prevail in each market, and what profits each firm will make.

Each firm has to decide whether to serve each national market and, if so, where to locate its production for that market. Each firm serves a given market from a single location, but can serve different markets from different locations, if it wishes to do so. Whether a firm becomes an MNE depends on the choices that it makes; if it decides not to produce abroad then it does not become an MNE. It is assumed to begin with that headquarters and R&D are collocated at a fixed location. Firms with inferior technologies may not operate at all.

Consider a set of tables summarising the solution of this problem. One subset of tables relates to production and trade. For each firm there is an $N$x$N$ table showing how much it supplies from each production location to each market. There are $H$ firms and therefore $H$ such tables and, taken together, they have a total of $HN^2$ cells. There is a smaller table with $N$ cells recording the prices that prevail in each market, and another table with $H$ cells reporting the profits made by each firm (firms that do not operate make a zero profit). The solution is therefore encoded in $HN^2 + H + N$ cells. This number is a measure of the 'tabular complexity of the solution'.

The solution varies according to the assumptions on which the theory is based. Suppose that there are two general principles: that firms maximise profit, and that they compete for market share in each country. Suppose, in addition, that each customer in each market demands a fixed amount of each product, and refuses to pay more for the product than some reservation price, $p^*$. Then the amount of product demanded in each market at or below the reservation price is some amount, $q$. The prices and quantities demanded vary across markets according to local population, incomes and tastes.

Suppose also that there are constant unit costs of production and transport, and that there are no fixed costs. Let the total cost to firm $h$ of supplying a unit of product from a plant in location $i$ to a market $j$ be $c_{hij}$ ($h = 1,\ldots, H$; $i, j = 1,\ldots, N$). The elements $c_{hij}$ are measured gross of production costs, transport costs, tariffs and technology transfer costs. They number $HN^2$ and constitute the elements of $H$ individual $N$x$N$ tables, each of which represents the cost structure faced by an individual firm.

The other quantitative data required to specify the problem concerns the structure of the individual markets; the amount of the product demanded in each market, $q_j$, and the maximum price that consumers will pay $p^*_j$ ($j = 1,.., N$). The data is therefore contained in $HN^2$ unit costs cells, a column of $N$ market sizes and another column of $N$ reservation prices. These comprise a total of $HN^2 + 2N$ cells. This is almost the same as the number of cells that need to be filled by the solution; indeed, if there were no reservation prices (so that each market was always served) then the two would be identical). This number represents the 'tabular complexity of the data'.

Each firm can serve any given market from any location; one option is to serve a market by local production, and the others are to import from plants in other locations. Each firm plans to serve a given market from the cheapest location, i.e. the location $i^*_{hj}$ where its unit cost is a minimum, $c^*_{hj} = min_i\, c_{hij}$.

The firm with the lowest cost, $c^{**}_j = min_h\, c^*_{hj}$ will serve the entire $j$th market. They will drive out their competitors by setting price just below the unit cost of their closest competitor, which is the firm with the second lowest unit cost. There are two exceptions, however. If the lowest unit cost is above the local reservation price then no firm will serve the market at all; and if the second-lowest unit cost exceeds the reservation price then the firm will charge the reservation price because otherwise it will lose the market altogether.

Let $p_j^*$ be the price set in the $j$th market when that market is served by its least cost firm. Let $q_j$ be the size of the market, as measured by the quantity of sales. Revenue is equal to $R_j = p^*_j q_j$, and cost is $C_j = c^{**}_j\, q_j$. In the absence of fixed costs, the profit of the firm serving the $j$th market is $\pi^*j = R^*j – C^*_j$.

There is no limit to the size or geographical diversification of any firm. Its decisions about whether to serve a particular market are not constrained by its decisions to serve other markets. According to this competitive outcome, some firms may be entirely domestic, serving their home market by local production; some may serve their home country only by imports; whilst others may produce in the home country for export, and perhaps for their domestic market too. Some may serve one or more foreign markets, either by exports from their home country or from a third country.

By counting up the number of arithmetical operations involved in the solution process a measure of 'computational complexity' can be obtained; such measures are widely used to assess the efficiency of computer algorithms. The solution involves four main steps, as indicated above. The first step is to determine for each firm the least cost production location from which to serve each market, and the unit cost associated with it. This is effected by moving along the list of location-specific costs for each combination of firm and market and recording the lowest figure. This process involves $HN^2$ operations. The second step is to compare the costs across firms for any given market; it is the least-cost firm that serves the market. This involves $HN$ operations. The third step is to determine market prices by calculating the minimum of the reservation price and the lowest cost in each market. If the reservation price is the minimum then the market is not served. If the least cost is the minimum then it is necessary to compare the second least cost with the reservation price. Whichever is the minimum determines the market price. This involves reprocessing the information obtained at the first stage; the amount of reprocessing depends on the number of firms involved. Overall, therefore, the calculations involve a minimum of $HN(N + 1)$ operations; this may be regarded as a measure of the computational complexity.