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LINKING ENTERPRISE FLEXIBILITY TO STRATEGIC OPTIONS: A CONTROL PROBLEM APPROACH

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ABSTRACT: In order to operate effectively, industrial enterprises must be able to coordinate and utilize their limited physical and managerial resources effectively to deal with uncertainty and complexity, following certain strategic options and guidelines. Enterprises must be able to acknowledge the tensions between flexibility and stability forces operating within them, and then manage them in a way that best reflects their strategic options. This paper looks at manufacturing enterprises as complex dynamic systems operating under certain strategic guidelines and constraints in order to be both effective and efficient. At the same time, they ought to be stable yet flexible enough to be able to deal effectively with perturbations, generated both within and outside of the system. In this higher level control problem approach to enterprise flexibility it is examined how both properties: flexibility and stability depend on the meta-controllability of the enterprise system. That is the control over the enterprise control system, the role of management in the meta-controllability of the enterprise, and how these control actions, which determine when, where and how much flexibility is applied, are linked to specific strategic needs and objectives that reflect the strategic options of the organization at the operational, business, and corporate level respectively.

Keywords: Control System. Meta-controllability. Flexibility. Strategic Options. Performance Measurement.

1 INTRODUCTION

In order to operate effectively, industrial enterprises must be able to plan, coordinate and utilize their limited physical and managerial resources to deal with uncertainty and complexity at different levels of the organization, following certain strategic options and guidelines. For this, they must be able to acknowledge the ongoing tensions between flexibility and stability forces operating within them, and then manage them in a way that best reflects their strategic options.

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This paper looks at enterprises as complex dynamic systems, which operate under certain strategic guidelines and constraints and, at the same time, ought to be flexible enough to deal effectively with perturbations, generated both within and outside the system, which affect the system differently. In order to guarantee on the one hand effectiveness and stability of operations and, on the other hand, the achievement of the enterprise strategic objectives. We can think of the enterprise as a dynamic system in constant need of control, coping with both the need to be flexible and malleable in order to change and adjust itself in different orders of magnitude and frequency upon requirements being impressed upon it. In addition, at the same time, the need to be robust and steadfast in order to be resilient (SHEFFI, 2003), achieving robustness in operations, even when it is called upon to act in such a way as to push itself to the limits.

This paper employs a control systems approach to enterprise flexibility, viewing both flexibility and stability (GALTIER; GAUTIÉ, 2002; WILSON; PLATTS, 2010) as desired properties of the industrial enterprise, both equally important and necessary for the enterprise system to be viable. Moreover, both flexibility and stability depend on the meta-controllability of the enterprise system.

Thus, the role of top and middle management (which is called upon to exercise such control) is a key factor, along with how these control actions – which determine when, where and how much flexibility is needed at any one time – are linked to specific strategic needs and objectives, which are part of the organization's strategic framework at the operational, business, and corporate levels respectively. But first let's define both terms.

Flexibility is first of all the capacity of an enterprise to respond to change. It is also the property of an enterprise system to be malleable and capable of adjustment in order to change and accommodate its operations to scenarios or environments other than those for that it was specifically designed (DA SILVEIRA, 2006). The flexibility of a system may also be viewed as the capacity of an enterprise to be managed successfully in order to meet its objectives, being capable of withstanding stress and strain without causing significant cost or any other type of impair or prejudice to the enterprise (SLACK, 1989; DE TONI; TONCHIA, 1998; HARWOOD, 2004).

Stability is, on the other hand, the quality or attribute of an enterprise system of being robust, resilient (SHEFFI, 2003) and steadfast in maintaining regularity of operations even upon extreme conditions. It may also be viewed as the quality or property of an enterprise to preserve its equilibrium when undisturbed (or only slightly disturbed) but able to pass to a

more stable equilibrium when sufficiently disturbed. In sum, we may say that stability is the quality or property of an enterprise system to maintain its course in spite of forces acting upon it. It is management the one that is called upon to establish the right balance between stability and flexibility in the enterprise, understanding that both are desired properties or qualities of the system, which must be engineered in the enterprise system itself, not added onto and which do not oppose one another.

2 THE META-CONTROLLABILITY OF THE ENTERPRISE

Meta-controllability, as the term signals, is the highest level of control within the enterprise, the control over the enterprise's control system, and it rests basically on the shoulders of management.

It is indeed the control of all other control layers of the firm, and it is responsible for coordinating, amalgamating and effectively leveraging the multiplicity of control actions taking place and resources being used at any one time in the enterprise. Whether these may be managerial, infrastructure, organizational and cultural, technological or strategic, in order to secure a coherent and successful use of the enterprise's limited physical and managerial resources to deal with uncertainty and complexity following a set of specific strategic guidelines, normally laid out on the enterprise's mission and vision statements.

On the other hand industrial organizations are essentially open, living systems, which are constantly faced with various forms of uncertainty, instability and complexity yet requiring continuity/stability, clarity of purpose and an adequate degree of flexibility at every level of the enterprise system to operate in a rational manner (MELIN, 2010). In the case of uncertainty, flexibility can be seen as the ability to deal with the unexpected, both within and outside of the enterprise. The main issue appears to be whether the measurement of uncertainty is adequate for either perceived and objective approaches.

Organizations no doubt need stability as much as they need flexibility in order to operate, because if everything about the organization were to be always changing or change without latitude, the organization would be crippled by chaos and disarray. Hence, some aspects of organizations must change in a controlled fashion when it is necessary to do so, making it possible for the enterprise system to survive, and even exploit the benefits of changes both inside the organization and in its environment.

We can try to understand how to establish the right balance between enterprise flexibility and stability, by looking at the enterprise as a control system. Thus depending on

the need or objective being presented upon the system, the enterprise alternates between flexibility and stability phases all the time, in different measures and extent, depending on the situation being faced. Furthermore, we assert that the system needs to apply its different types of flexibility constructs to compensate for uncertainty and risk at different levels of the system, but always in correspondence with the strategic needs and objectives of the enterprise (CARLSSON, 1989). This is the ultimate proof of enterprise flexibility's effectiveness.

Flexibility is desired in order to handle uncertainties and variations in both internal and external environment. It has been correctly asserted that flexibility is a multi-dimensional concept (GERWIN, 1993; UPTON, 1994, 1995), and like agility and simplicity, it is also a property of manufacturing enterprises that can be interpreted and measured differently (WADHWA; MISHRA; CHAN 2009) at different levels of an enterprise system. In addition, as it has been said, it holds a different meaning at different levels of the enterprise system depending on the means by which it is to be achieved.

Since at any point in time there are multiple situations and conditions affecting the enterprise system, and these are associated with different levels of uncertainty and variations, different sorts of flexibility at different levels of the enterprise system are needed. These levels are impacted by the different elements, which comprise the organization.

Most authors focused on either exploring the relationship between flexibility and performance or building conceptual typologies or taxonomies (NAYAK; RAY, 2010, 2011), but without addressing the flexibility issue as a property which must be built in the enterprise system. Likewise, few studies have focused on the links between flexibility and operations improvements under a certain strategic framework.

Both stability and flexibility are indeed indispensable for the enterprise's viability as a dynamic system, but more importantly, they are not properties, which are independent of the enterprise system, nor may they be added to it or taken away from the system simply as an accessory. These are both fundamental properties of the enterprise system itself and they must be engineered effectively in its control system in order for this to adequately respond to the enterprise's needs and objectives.

2.1 The entropy analysis: a road not taken

Unlike other authors such Kumar, (1986, 1987), Shuiabi, Thomson and Bhuiyan (2005), Piplani and Wetjens (2007) who choose to view entropy as a measure of operational flexibility and seek to analyze entropy and entropy generating factors as determinants of

enterprise flexibility, following the logic of entropy maximization as a way to foster and generate higher degrees of flexibility in operations. The view of this paper however is that flexibility is not directly linked to entropy and therefore entropy analysis and much less, entropy maximization is not the right course as a means to maximize flexibility.

On the contrary, entropy is not necessarily a good thing, and indeed too much entropy might be detrimental to the purpose of generating higher degrees of flexibility. Entropy is a measure of disorder in the enterprise system, and the more information (in all its forms) there is in the system, the more entropy there is. Too much information and too many choices can lead to disorder and immobility, just as we feel overwhelmed when going into a supermarket and looking for soap only to find that there are so many options to choose from that to even think of analyzing which one is better is just mind boggling.

Unless flexibility has been carefully engineered in the enterprise system by judiciously designing which alternatives ought to be present in every element of the enterprise control system, too much to choose from can be negative, and lead to rigidity, inefficiency and disorder. Perturbations come from outside and from within the system, and both have to be dealt with differently.

While flexibility needs are important in hindering adverse effects of unexpected changes and disturbances coming from outside the system, it is equally important and necessary for management to deal with disorder and chaos springing within, at different levels and sections of the manufacturing system. Both types of uncertainty and change are different in nature and require a different treatment. Therefore, the enterprise control system is called to act upon the different types of perturbations affecting the enterprise system at different levels by deploying the necessary control actions to overcome such perturbations.

Thus, the need for flexibility as well as stability is always present. As in a dynamic environment, the two terms seldom balance each other for any extended period of time, so in the real world systems tend to fluctuate around the states that define their steady states, rather than settle into them without further variation. So enterprise systems tend to fluctuate between stable conditions (steady state) and changing conditions (uncertainty provided by variations) which require the system to be flexible, but within certain defined guidelines and boundaries, to cope effectively with these changes. Hence in order to display its flexibilities, enterprises generally move from a state of higher organization (more stable state) to one of lower organization (higher entropy level), from order to disorder.

2.2 System Controllability: engineering a proper use of enterprise flexibility

While flexibility measures may be well prescribed for treating unexpected variation from outside factors, which threaten the system with disorder and disarray, the same prescription may not be used just the same and to the same extent for unexpected variations and their derived uncertainties, and then expect similar results.

For instance, variations and their derived uncertainties may be dealt with effectively in terms of increasing stocks of raw materials, when there is uncertainty about the availability of the required types and quantities of materials due to external conditions such as reliable suppliers or shipment not readily available. On the other hand, an enterprise wanting to produce for stock of finished products when there is uncertainty as to how much the demand for a certain key product may vary over a certain period, risking expected sales figures.

However, in the case of perturbations arising within the system, as for example an unexpected machine breakdown. The unexpected problems with a machine's set-up or a key machine operator falling sick and not reporting for work are just a few examples of adverse situations that are quite different from outside perturbations and uncertainty in the sense that these factors. Which are but a small part of a long list of factors and conditions, which are part of the system itself. They are factors and conditions that are dependent upon the structure and organization of the manufacturing enterprise system, and as such they are built in the system, and depend essentially on the right managerial decisions, aided by an adequate operations and business strategy to structure measures to fend off such perturbations effectively.

Therefore, while perturbations and uncertainty coming from outside forces may be more readily understood and more clearly dealt with and the flexibilities measures required to deal with them and their strategic linkage more readily apparent to the trained observer. The conditions that originate perturbations and uncertainty within the system are, for the most part, factors, which depend on the way the manufacturing system is structured and organized and on the resources built into the system.

Thus to deal effectively with inside forces that cause perturbations and uncertainty (lack of stability) in the manufacturing system, management has to consider first and foremost such vital aspects as the manufacturing and business strategies of the enterprise, and how well the enterprise organization and structure are aligned with these strategies. In addition, make sure that the manufacturing enterprise system as a whole is appropriately endowed with the necessary resources, both physical and human, and the management and administrative

policies needed to ensure that the system is able to sort out adverse situations and conditions effectively.

Therefore, appropriate measures of flexibility at different levels of the enterprise system are part of these resources, and it is a matter of how well and how appropriate these flexibilities measures are engineered in the enterprise system, which determines how capable is the system when it comes to responding to these adverse conditions; and how apt and effective it is at maximizing its performance despite its limitations and perturbations.

3 LINKING ENTERPRISE FLEXIBILITY TO SPECIFIC CONTROL ACTIONS

Companies are increasingly concentrating on flexibility as a way to achieve new forms of competitive advantage (SHEREHIY; KARWOWSKI; LAYER 2007). Strategy should influence manufacturing flexibility requirements and hence the choice of production technology (GERWIN, 1987).

As Palominos (1996) put it, when referring to the textile manufacturing industry, the enterprise production system's capacity to respond must be addressed from a broader and more general perspective, which, in our view must necessarily account for the strategic implications of enterprise flexibility. This approach to flexibility we feel is appropriate, rather than trying to reduce flexibility to a particular subset of system and analyze it just from the operations point of view without linking it to the enterprise's strategic framework.

Thus we feel that this concept of flexibility is not only more appropriate, as viewed from a wider perspective, but also more effective in terms of measuring the system's responsiveness to change and how this affects the enterprise standing in terms of its strategic framework, whether it be at the corporate, business or operational level.

Furthermore, flexibility at each level means different things, as it is associated with specific needs and objectives that are particular of the level and area/department of the enterprise at any given time. These specific needs and objectives must in be linked to specific strategic goals of the enterprise.

For example in operational flexibility, it makes sense that the enterprise system may have multiple routing options for any given product's manufacturing, a flexible, multidisciplinary workforce, a variety of flexible machines, that can manufacture multiple parts of a product or family of products. And that can also be reconfigured to handle other tasks such as adding finishing and other special customization characteristics to a particular

product. At the business level, on the other hand, flexibility may take the form of financial flexibility, sales and marketing flexibility, flexible merchandizing or distribution flexibility.

Finally, at the corporate level, the corporation must be able to tap on new markets when conditions merit so, or change to a new market when a particular market it is in is declining or becoming obsolete, and for example, build a new plant when particular market demand conditions so requires it. Understood this way, flexibility is not only coherent but also strategic (GEBAUER; LEE 2008; MACKINNON; GRANT; CRAY 2008).

Hayes and Wheelwright (1984), Argyris (1985) point to flexibility as a basic element of a firm's competitive advantage, thus underlining the strategic character of flexibility as a desired property of manufacturing systems. Skinner (1978, 1985), on the other hand, argues that flexibility may be considered in a strategic context, particularly in the investment process. Figure 1 show the model whereby flexibility may be achieved by means of control actions of the enterprise, and a feedback control system represented by a performance measurement linked directly to strategic needs and objectives and to the control system itself.

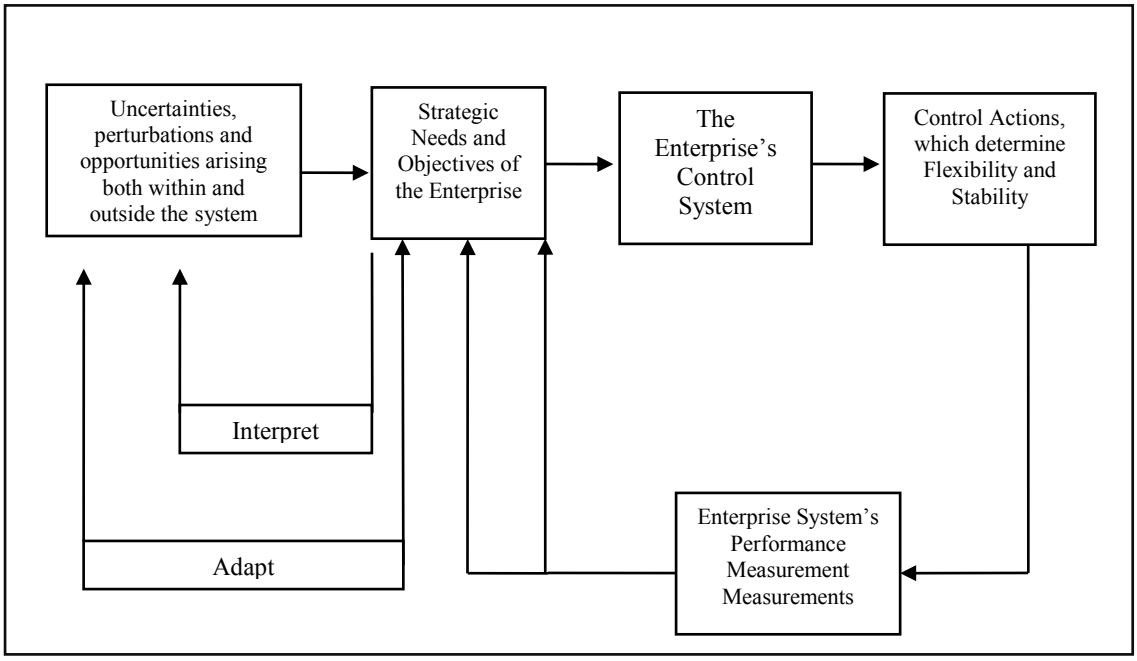

Figure 1 – Control System Approach Model to Enterprise Flexibility
Source: Author's elaboration

It is important to note here that flexibility must be viewed as a necessity of the enterprise to survive, just as stability or continuity is a permanent need of the enterprise system upon reaching steady state. Therefore, flexibility is not a goal in itself but means to an end. It is being flexible and agile when conditions affecting the enterprise so requires it that the enterprise may be able to achieve its strategic needs and objectives and not the other way

around (IZZA et al. 2008). Thus, flexibility measurement is not relevant in itself but only when it is viewed in the context of the strategic needs and objectives of the enterprise that the measure of flexibility helps to achieve (PALANISAMY; SUSHIL, 2003).

It is important to point out that the issue of flexibility types (CANIATO; SPINA; GAGLIAO, 2004) and their incorporation at different levels of the enterprise system has been put forward by many researchers before, who present different research approaches to the flexibility problem in manufacturing systems, and lay out the basis of their postulates for future research to follow. However, three fundamental problems remain (PALOMINOS, 1996), these are:

- The need to define, in precise terms, which type of performance measurements (KAYAKUTLU et al. 2011) are they making reference to when they talk about flexibility in manufacturing; so that it may be possible to establish comparisons among different factories.
- The metrics of flexibility continue to be a problem that needs to be address in a more general way, since a given measure of flexibility that may be adequate for a manufacturing enterprise, may not be a representative measure of such flexibility when applied to another enterprise;
- The little knowledge available on the principles that rule the different types of flexibilities.

Finally, the Control System Approach Model offers a way to build adequate set of control actions oriented to allow flexibility and stability, taking into account strategic needs and objectives of the Enterprise

4 LINKING ENTERPRISE FLEXIBILITY TO STRATEGIC OPTIONS

In order to carry out an immense number of complex operations and tasks, which in turn demand a multiplicity of complex decision-making processes. All of this in very dynamic environments, manufacturing enterprise systems must decide, upon uncertainties and unpredictability arising both from outside and within the systems, when and how to plan and when to act, how to detect and recover from errors, how to handle conflicting goals and decisions, etc.

In short, management at every level of the manufacturing enterprise must effectively plan, coordinate, and control their limited physical and human resources, trying to optimize

the systems' outcomes as a result of transformation of their given inputs and outputs at any given time.

As the tasks and decision-making environments become increasingly complex, explicit constraints and boundaries are needed to impose a certain structure on the control of planning, perception and action of the systems to improve system performance. And to ensure that they are able to operate effectively within a specific operational framework which delimits their flexibility in operations and ensures that their decision making options are mapped to specific strategy options and not the other way around.

This we feel is essential in making sure that the systems will achieve their goals while strategic options remain secured. In our view, this approach handles uncertainty and unpredictable changes better, since it reduces the amount of entropy and complexity being produced within and outside the manufacturing enterprise system.

However, it is unclear how systems can maintain their balance between flexibility and stability requirements and at the same time keep their strategic coherence as tasks and environments increase in diversity. The problem is that, as manufacturing systems grow bigger and more versatile, complexity increases and so does entropy, hence complex interactions among decisions and actions within the system increase. As well, to the point where it becomes difficult to predict the system's overall outcome, measure its flexibility-linked effectiveness and much less secure the link between this effectiveness and the enterprise strategic options.

One way in which we can try to limit the amount of flexibility in the enterprise system to a level and scope that is adequate and manageable based on system's requirements and objectives, is to limit the options available in operations (too many options and too much leeway in operations is just as bad as not having options at all), thus preventing it from spanning out of control.

This may be achieved by adding top-down constraints upon the system's available actions and allow it to take advantage of regularities in its domain to coordinate actions in a more recursive fashion, thus reducing entropy and complexity at different levels of the system and, in this way, preventing or at least attenuating these adverse conditions from happening. Good examples of this can be found in Lean Manufacturing and the Rigid Flexibility Model, both cited previously as examples of what we call a controlled approach to manufacturing enterprise flexibility.

The approach advocated here, which we term meta-controllability of the manufacturing enterprise system, is basically one in which, like Lean Manufacturing and the Rigid Flexibility Model, strategic options are closely linked to and secured by their operational and business strategic framework by means of adequate control actions of the system. System reliability and effectiveness is increased by using an operation model whose pillars are adaptability, simplicity and agility, maintaining specific operational constraints and system's boundaries to secure its quick, agile and effective response and incrementally layering on additional options in operations behavior to handle exceptions and extreme, unbounded situations.

Thus, the separation of regular/nominal and exceptional behaviors of the enterprise system increases system understandability and controllability by isolating different concerns: the manufacturing enterprise system's behavior during normal, regular operations and conditions is readily apparent, and its efficiency and responsiveness are maximized, while strategies for handling exceptions can be developed as needed. Furthermore, complex interactions are minimized by constraining the applicability of behaviors to specific situations, so that only manageable, predictable subsets will be active at any one time.

5 META-CONTROLLABILITY OF THE ENTERPRISE SYSTEM: TYING THE KNOT BETWEEN FLEXIBILITY METRICS AND STRATEGIC OBJECTIVES

Currently, organizations in general, and particularly manufacturing enterprises, fluctuate between periods of stability and change in the course of their operations almost permanently. The degree of stability and change in the enterprise system also fluctuates, depending on a myriad of factors. This becomes even more so as production transits from low season sales to high season during the course of a regular year, and it is more evident toward the end of the month, as work orders pile up disputing scarce manufacturing resources such as equipment and machinery, labor, materials and time for processing.

The control system of the enterprise, which we have termed meta-controllability, is in turn comprised of five basic elements. These elements of the enterprise must be strategically interconnected and operate closely intertwined in order to correctly determine the enterprise requirements for flexibility (or stability) at any given time, and what control action is needed to generate such flexibility. Figure 2 shows this construct and its relations with one another. The five basic elements, which determine tea controllability if the enterprise systems are:

- Enterprise management.

- Strategic goals and management policies at all levels.
- Organizational structure and culture.
- Enterprise infrastructure.
- Technology.

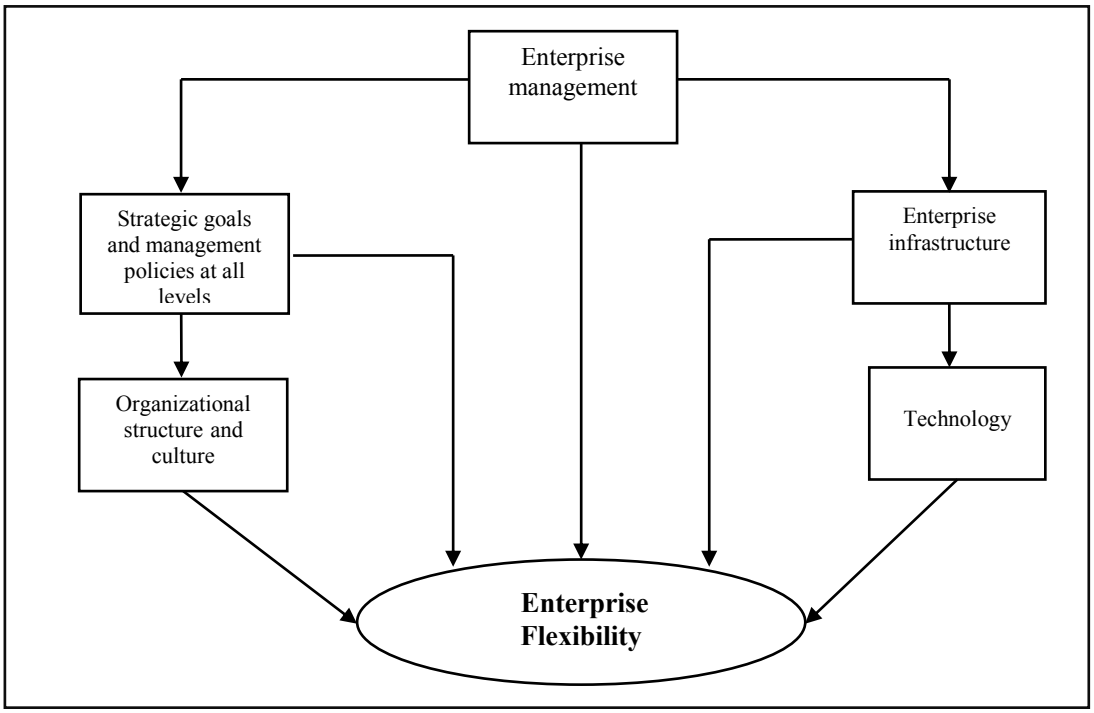

Figure 2 – The 5 basic elements that comprise the control system of the enterprise
Source: Author's elaboration

However differently, they all impact both enterprise flexibility and stability capabilities and determine the enterprise system's viability in terms of its capacity to adequately manage both. The above fundamental elements, which comprise the control system of every organization, particularly manufacturing enterprises, and how these elements are ensemble and coordinated, will ultimately determine the type of organization, its control capability and operational characteristics, and most importantly, its capacity to effectively manage and satisfy the enterprise system's needs for flexibility and stability.

The most important of all five is of course the enterprise management, as it is management indeed the main articulator, and as we said earlier, it is upon management shoulders that the meta-controllability of the entire enterprise system rests. Hence, at the heart of the system there is always management, which is responsible for the right and timely interplay between flexibility and stability at every level and in every unit of the company.

The degree and extent to which flexibility and stability are to be used in the enterprise system, as well as the lack of either one, at any one time, depends on enterprise management

capacity and skills to articulate all these elements correctly at every level of the enterprise, and on the other four elements being adequately designed and implemented to sustain the enterprise control system capabilities.

However, management alone is not enough. It is fundamentally important to distinguish how the different elements are assembled in the organization and the logic and coordination behind this assemblage.

6 DESCRIBING THE DIFFERENT TYPES OF ENTERPRISE FLEXIBILITY

The different elements which comprise the control system of the enterprise give birth to different types of enterprise flexibility as each element's flexibility contribute to the enterprise flexibility differently although they all complement one another. Although, each occupies its unique place and ranks differently in the contribution hierarchy to enterprise flexibility, with management flexibility at the top, they all contribute their share to accomplish enterprise objectives. Each one of the five types of enterprise flexibility is described as follow:

Management flexibility: it is defined as the capacity of management to respond to change (EROL; MANSOURI; SAUSER 2009), and to be able to adjust its policies and management style in order to create the necessary conditions within the enterprise system for the enterprise to become effectively responsive, agile and recursive in its actions toward the need to adapt to changes, whether they present themselves in the form of perturbations or opportunities coming from inside or outside the enterprise system.

Flexibility of strategic goals and management policies at all levels: strategic goals and management policies of the enterprise at all levels, on the one hand ought to be flexible enough so that they may change and adapt to ever changing conditions and unforeseeable situations, which may affect the enterprise. Rigid, inflexible strategic goals may ultimately turn against the enterprise viability by not allowing it to shift gears when the circumstances call for it.

Flexibility of organizational structure and culture: Organizational structure and culture are both determined by the enterprise management and its influence is gravitating at all levels. Therefore, it is crucial to build a highly flexible organizational structure and an enterprise culture, which supports and enhances this property, this way engineering flexibility in the enterprise's spinal cord. Organizational structure is, as it was pointed out before, a major determinant of enterprise flexibility

Enterprise infrastructure flexibility: the types of infrastructure being used in an enterprise system are in themselves a major determinant of flexibility. Being subordinated to management's decision, infrastructure accounts not only for manufacturing plants, storage facilities and office buildings but for all types of workspace arrangement within the enterprise, including energy, power systems, and other systems which make possible to operate the enterprise at all levels. The infrastructure is in itself a key player in the flexibility issue.

Technology flexibility: is a key design of flexibility and thus it must be chosen correctly. From advanced manufacturing technologies to modern information and communications technologies (LANKHORST, 2013) they all impact flexibility in the enterprise at different levels and in different ways, but no doubt they play a major role in the enterprise control system.

Technology in all its forms is a key determinant of enterprise flexibility anywhere, particularly in manufacturing. Advanced manufacturing technologies of various kinds have emerged over the last fifteen years, particularly with the rapid advent of advanced manufacturing automation solutions and the advancements in industrial robotics.

The measure of flexibility is simple: it is given by what the technology allows operations to do at every level. From the executive offices to the manufacturing floor, whether it is an ERP system that provides multiples advantages and enterprise-wide flexibility in terms of information access and processing to advanced, state-of-the-art manufacturing systems, which are capable of quickly and easily reconfigure themselves to be used in a variety of product customization options or in new product lines altogether.

Figure 3 below shows the meta-controllability of the manufacturing enterprise system, represented by management and its actions upon the rest of the enterprise control system elements. The model shows the elements' interconnectedness and the flexibility metrics linked to performance measurement compatibility. It is evident, by looking at the sketch, that management is the key player in the controllability of the enterprise system, and as we said earlier, it is at the very top of the hierarchy within the five elements, which make up the control system of the manufacturing enterprise.

The strategic options chosen by management, on the other hand, must clearly reflect the needs and objectives of the company and if misalignments were to occur as identified by the enterprise performance measurement system, appropriate actions ought to be taken, in the

form of control actions, in order to correct the problem and thus allow the enterprise system to thrive.

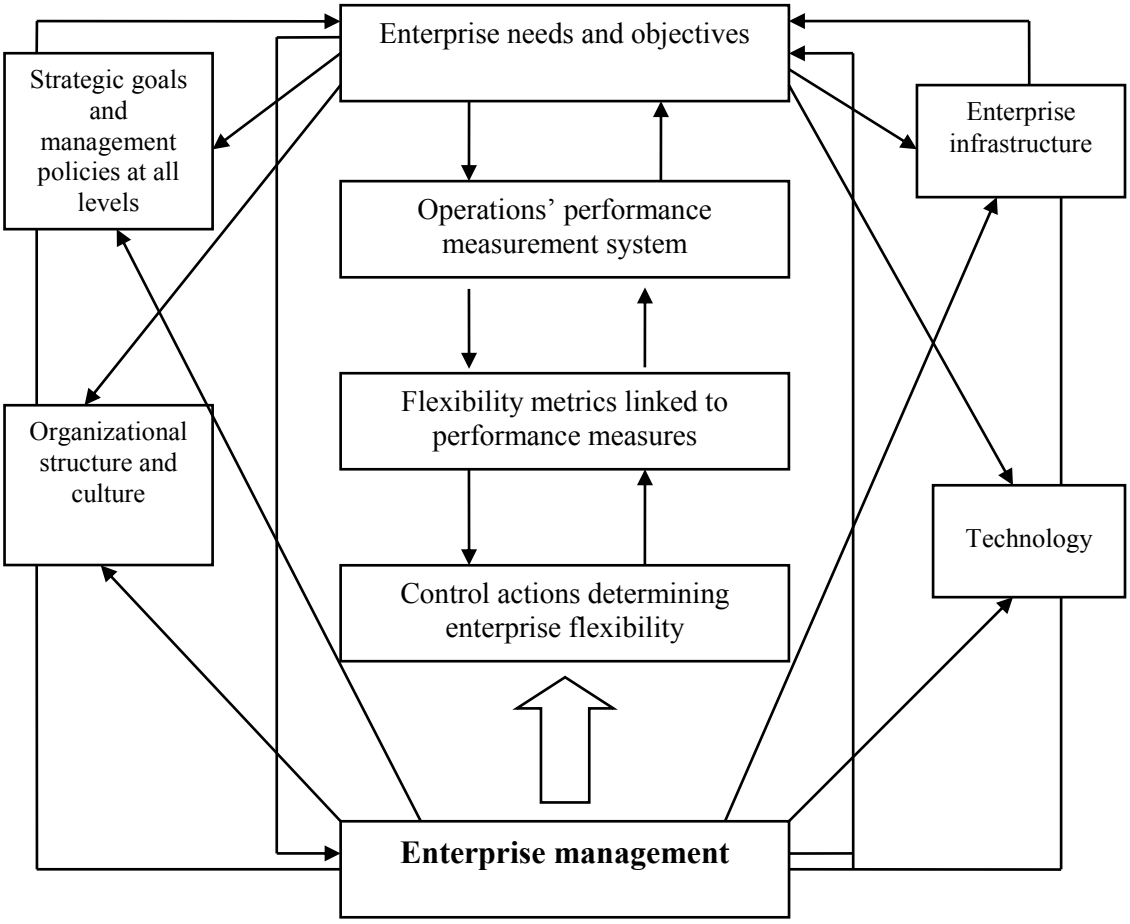

Figure 3 – Meta-controllability of the manufacturing enterprise system, its interconnectedness and the flexibility metrics linked to performance measurement compatibility
Source: author's elaboration

As the Figure 3 shows, enterprise needs and objectives, placed at the top of the hierarchy, constitute the basic beacon, which must guide the management's efforts to engineer enterprise flexibility at every level. Enterprise needs and objectives are clearly impacted by all the elements in the control system, which in turn are controlled by management. Thus, we have termed management the meta-controllability of the enterprise.

Management is at the bottom of the top down model symbolizing the foundation (at the base) of the model. Thus, everything rests upon management shoulders and although the other four elements are clearly linked within the enterprise and their action is systemic, influencing enterprise flexibility in terms of their scope of operation and particular role in the enterprise system. It is management which ultimately determines the other four and their successful interaction as well as the dynamics taking place in the ladder comprised of control actions

determining flexibility; flexibility metrics linked to performance measures; operations' performance measurement system and finally the top of the ladder, enterprise needs and objectives.

Therefore, we can say that enterprise flexibility, being a desired property of the enterprise system, whose action is indeed systemic in nature, is strongly leveraged by enterprise management and the success with which they can manage the different elements, which comprise the control system of the enterprise, including management itself.

7 IMPLEMENTING FLEXIBILITY METRICS IN TERMS OF ENTERPRISE PERFORMANCE MEASURES

Determining what to measure can take considerable effort when the right focus is not in place. In order to build an efficient and effective enterprise control system, a measurement system equally efficient and effective must be in place since as everyone knows, we cannot control what we cannot measure (RAMASESH; JAYAKUMAR, 1991). Data collection and processing systems for all enterprise operations that are tied to flexibility metrics will have to be implemented to produce the measures; everyone involved will have to be trained in using the systems and measures at every level; and as the measures are used, some problems are sure to be identified that will require changes to the system.

Certainly, developing the appropriate measures to have the ability to determine if sales and profit problems are caused by strategic options, operations, or both and how much of a factor it is the flexibility factor in the equation is not an easy task. Perhaps the greatest challenge faced when implementing flexibility metrics, in terms of enterprise performance measurement systems, is changing an organization's culture.

We must not forget that culture is one of the key elements of the control system itself, and therefore its adequate disposition toward work flexibility and change must also be measured as well as measuring how proactive and effective the work force is in terms of accomplishing enterprise objectives that are closely linked to culture flexibility. This is of course a task that must be realized by enterprise management, which, as we saw earlier, is at the top of the hierarchy in the enterprise control system, the control over the control if you will, and thus it is responsible for the meta-controllability of the whole enterprise system.

Using performance measures requires managers and employees to change the way they think and act. For most people, this is relatively easy, but for some, changing old beliefs and habits is very difficult. Overcoming such problems requires strong leadership to provide

appropriate direction and support. The best measurement system in the world will yield few benefits if the right knowledge, skills, abilities, and values are not developed in a company. We must understand that an organization does not just interface with a measurement system; it must be part of the system itself. Therefore, we propose elaborating concrete flexibility measures that are linked to the five fundamental elements, which comprise the enterprise controllability.

In order to have a good assessment of our enterprise control system performance in terms of being able to act quickly and effectively to provide the appropriate measures of flexibility and stability being required (control actions) by the enterprise, we have to develop an adequate measurement system. If we are to measure flexibility in the manufacturing enterprise, we have to make sure that appropriate flexibility metrics are developed that are adequately linked to the strategic needs and objectives of the enterprise. Hence, we first have to make sure that we know what to measure in order to measure it well. Developing and implementing effective measurement systems requires leadership, commitment and hard work and we have to make sure that this effort will not go to waste.

Every company is different but one can start by looking at the core processes of the company and how these processes performance which span throughout the enterprise, may be affected (hindered) by flexibility problems ingrained in the organization; which can be linked to factors belonging to the five basic elements which comprise the controllability of the enterprise system, namely management flexibility (PALANISAMY; SUSHIL, 2003; GEBAUER; LEE, 2008;).

These are: Flexibility of strategic goals and management policies; flexibility of organizational structure and culture; infrastructure flexibility, and technology flexibility. Hence, it is all too important for industrial enterprises to realize that enterprise flexibility is a key catalyst of enterprise performance at the organizational, operational and business level and that flexibility in itself is a goal that must be sought. It is also important to understand that flexibility cannot be added or installed as if it were an addition to enterprise infrastructure.

Flexibility must be engineered in the enterprise system by developing and integrating the appropriate control capabilities in the control system itself, the five basic elements, which comprise the controllability of the enterprise. At the same time, enterprise flexibility must clearly reflect the company's strategic options since it is in how well these are served that the degree and success of enterprise flexibility may ultimately be measured. We believe that the benefits that may be obtained by achieving the latter can be in part summarized as follows:

- The ability to know what to enhance and what to prioritize in terms of the organization; operations and business needs in order to align with enterprise strategic options, making sure that these indeed represent the enterprise needs and objectives.
- Early identification of problems with the elements, which comprise the enterprise control system and opportunities to correct them; the ability to reach the right balance between stability and flexibility in the manufacturing enterprise: that which allows for maximum enterprise performance without jeopardizing the system viability.
- Increased productivity, quality, and customer service at no extra cost to the enterprise system. When there is perfect alignment of operations and strategic options that effectively meet company objectives, the likelihood of having excess flexibility or not enough of it is little.
- A cohesive organization and a supporting culture working toward common goals.

8 CONCLUSIONS

Flexibility and stability are both desired properties of the enterprise system. They are both determined by the enterprise control system, which in turn is comprised of the five fundamental elements, which, although acting differently, have an impact on enterprise flexibility, as we explained earlier.

Flexibility as well as stability is systemic, and thus cannot be explained by isolated actions or relegated to a phenomenon that can be explained by entropy. Or worse to try to increase flexibility by resorting to additions in just one part or another of the enterprise system alone without considering the dynamics and interconnectedness of the enterprise system elements as a whole.

Management is responsible for handling the controllability of the system and therefore it is the control over the control, which we have termed the meta-controllability of the enterprise. Management is both, at the top of the hierarchy of the control system of the enterprise and also at the bottom, representing its foundation. It is management, which determines and controls the actions determining enterprise flexibility or the lack of it at every level of the enterprise system.

These in turn will be used to elaborate the flexibility metrics, which are linked to performance measures of the enterprise, and these metrics also will provide feedback to management in order to adjust and correct misalignments that may affect strategic options.

Flexibility metrics are useful for adequately supporting the Operations' performance measurement system, without which the control system would collapse and management would become blind to enterprise strategic performance. Thus, there must be feedback between the two as in every other case in order for the system to learn and adjust itself until it finds its right setting.

LIGAÇÃO DA FLEXIBILIDADE DA EMPRESA COM AS OPÇÕES ESTRATÉGICAS: UMA ABORDAGEM DE PROBLEMAS DE CONTROLE

RESUMO: Para operar efetivamente, as empresas industriais devem ser capazes de coordenar e utilizar os seus recursos físicos limitados e gerenciar de forma eficaz para lidar com as incertezas e complexidades, seguindo certas opções estratégicas e diretrizes. As empresas devem ser capazes de reconhecer as tensões entre as forças de flexibilidade e estabilidade que operam dentro da organização, e posteriormente gerenciá-los da melhor forma que reflete suas opções estratégicas. Este artigo analisa as empresas industriais como sistemas dinâmicos e complexos que operam sob certas diretrizes estratégicas e restrições, a fim de serem eficazes e eficientes. Ao mesmo tempo, eles deveriam estar estáveis e flexíveis o suficiente para serem capazes de lidar eficazmente com as perturbações, geradas dentro e fora do sistema. Nesta abordagem do problema de controle no nível superior da empresa a flexibilidade é examinada como ambas as propriedades: a flexibilidade e a estabilidade dependem da meta-controlabilidade do sistema empresarial. Esse é o controle sobre o sistema de controle da empresa, e o papel da gestão na meta-controlabilidade da empresa, com essas ações de controle, que determinam quando, onde e quanto a flexibilidade é aplicada, estão ligados a necessidades e objetivos estratégicos específicos que refletem as opções estratégicas da organização no nível operacional, comercial e corporativo, respectivamente.

Palavras-chave: Controle de sistema. Meta-contrabilidade. Flexibilidade. Opções estratégicas. Avaliação do desempenho.

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