# Exploring the effects of governance structure, relationship and upgrading in the solar energy value chain: a case study on Egypt

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**Abstract**
This study explores the governance structure(s) of the solar energy value chain in Egypt and the associated governance relationships and suitable upgrading types to be followed. Global value chain (GVC) theory is used to identify the operation mechanisms of the value chain and classify the relationships guiding the different structures.

**Keywords:** Solar Energy, Global Value Chains, Governance Structure

## INTRODUCTION

In-spite of the high potential of solar energy industry as a considerable opportunity for investment and the global focus in such sector, the solar energy industry is considered to be an immature industry due to the immaturity of the technology associated with it. Aligned with the high cost of investment this is considered a significant barrier to all parties or players involved in such value chain. Consequently and as to overcome such high risk a clear understanding to the solar energy value chain is crucial as well as understanding the type of governance structure(s) and governance relationship. Governance structure refers to the system that governs the interactions between parties within any value chain. As well as it considered an urging challenge to determine the best upgrading that each player should adopt as to enhance their performance and not to waste resources in a non-productive type of upgrading. Also it is even highly important for firms' developing countries to understand such prospective well as to be able to join the global value chain of such important and high tech industry.

The purpose this research is to identify the type of the global governance structure(s) and the associated governance relationship of the solar energy value chain and the appropriate type of upgrading should be followed by players. The study will focus on the solar energy value chain and on the involvement of the Egyptian players that is associated with such value chain as well as the corresponding upgrading associated with the governance relationship. The authors adopted the theory of Governance Value Chain analysis stated by Gereffi (2011) and Gereffi, Humphrey & Sturgeon (2011) as to identify the governance structure(s) and the lead players within the solar energy value chain. Consequently validate the types of upgrading that is optimum within each governance relationship proposed by Humphrey and Schmitz (2002).

## LITERATURE REVIEW

### The Value Creation Approach

The significance of studying value chain, comes from the urge of accessing the global market in the global production network which could ease the access to the developed countries. So, by analyzing and understanding the mechanism of the value chain, firms in emerging (developing countries) can gain access to global markets and consequently gain extra benefits not only from the financial and profit point of view, but also in terms of technology and even emphases its competitive edge (Gereffi, G., 2011). Governance Value Analysis, is considered to be the extension of transaction cost analysis. The aim of studying governance value analysis and creating a GVA model is to identify which governance structure should firms depend on and seek for as to achieve the value creation (Ghosh and John, 1999). The literature of the GVA model had presented a governance dilemma: value creation and value claiming are treated as inseparable process, it was suggested by (Ghosh and John, 1999) that firms should depend on their own analysis to solve such dilemma (Hammervoll, T., 2010).

### Global Value Chain Analysis

Global Value Chain analysis GVC, is recently gaining a worldwide attention due to its strategic analysis power for any industry as it focuses on the value creation and capture across the full range of possible chain activities for any industry and commodity (Gereffi, G., 2011). Giving a holistic as well as an insight view for the whole process and the influence of each player in the value chain network, focusing mainly on the (re)organization, coordination, governance and the power of chain (Gereffi, G., 2011). The core study of GVC analysis focuses on the interrelation between the concepts of governance and upgrading (Tejada, P., Santos, F. & Guzman, J., 2010). There are several studies on the global value chain analysis linking governance with upgrading (Gereffi, G., 1999). The main concern of GVC analysis focuses on the mechanism between various firms of global production and distribution system in the value chain. Moreover, the perspective of the transaction cost economies towards such interactions are organized. Furthermore, in transactions were access to information is scarce or comes with high cost or even no information are available, combined with conflict of interests between players in the same value chain, a proper coordination and collaboration between players is essential as to minimize the production and transaction costs. The GVC theory hypothesized that the different types of governance structure have a combination of three key variables; the complexity of information that is required for production including design and process, the ability to codify the transfer knowledge across the chain and capabilities and competence of the existing suppliers.

- Information complexity refers to the degree of sophistication of essential information and knowledge required to be transferred along the chain to ensure that a particular task is performed efficiently. The higher the sophistication, the harder the control and monitoring is, leading to high switching cost. If it's applicable a standardized process would be the solution.
- Information codification the ability to convert complex knowledge into standardized specifications to be adopted through the whole chain.
- Supplier capabilities refers to the competences of suppliers to perform all transactions required, in terms of quality, safety, specifications, skills and delivery. Also their ability to act as support services provider.

## Governance

Governance can generally be defined as interactions and coloration between economic parties within a certain chain. Several authors have addressed the concept of "governance", referring governance as the inter-firm coordination and the institutional mechanism attaining accomplishments through non-market synchronization (Tejada, P., Santos, F. & Guzman, J., 2010). Also "governance" can be stated as the unambiguous and understandable interactions between economic parties, were vertical integration, official as well as casual agreements, and all interactive norms are considered to be types of "governance" (Ghosh, M., & John, G., 2005). Another broad definition for governance is "a mode of organizing transactions" (Williamson, E. and Ouchi, G., 1981). From the perception of the transaction cost theory, governance is viewed as planning a certain mechanism as to sustain an economic transaction (Heide, J., 1994). The literature of the transaction cost theory and the original framework for the governance structure identifies the "governance" in to major structures, the market governance structure is best known as a price mechanism and arm length relationship and the hierarchal governance indicating an integrated authority structure (Humphrey, J., & Schmitz, H., 2002; Heide, J., 1994; Williamson, O., 1975). These two governance structure are considered an extreme opposite approaches.

The market governance is characterized by arm-length relationship between firms, where transactions are relatively simple and information exchanges are easily transmitted between parties, also suppliers proceed their operations with minimal output from buyers. The cooperation between parties are relatively informal and so changing partners between producers and buyers are easy and with low cost (no deep commitment). In this module the power mechanism is the price rather than the lead firms (Gereffi, G., 2011). Also in the market governance structure there is almost no commitment between parties allowing each player to easily modify or even change its approach as to get benefits from any opportunity that arises. This means that the switch cost is very low and there is almost no long term commitments. The market governance motivates players to innovate more and take higher risks. The main incentive in the market governance is relatively direct information regarding prices that is essential for effective operations (Hammervoll, T., 2010).

The other extreme of value chain governance structure is the hierarchical value chain, which is characterized by direct ownership for the whole production process through vertical integration adopted by the lead firms which control all steps starting from manufacturing until delivering to customers. This approach is mainly adopted for sophisticated products that cannot be codified or with absence of competent suppliers (Gereffi, G., 2011). Moreover, as it is considered to be a formal decision making authority legalized by contracts between parties. Basically the key players (lead firms) control the whole process. In such governance the creativity and innovation is only strict to the lead firms and then transfer it to all the subordinates or suppliers in forms of course of actions. And the incentives in the hierarchical governance is considered to be a reward system within such rigid structure (Hammervoll, T., 2010).

## Upgrading

The approach of global outsourcing has been raised since the 1970s, where big U.S manufacturer started to outsource their manufacturing subsidiaries to lower cost regions starting from Northwest and Midwest to the South and even went further by going across border to Mexico and finally to Taiwan and China. However, they maintained to have a full control over

design and marketing of it production (Gereffi, G., 2011; Hamilton & Gereffi, G.2008). The main driver behind global outsourcing and offshoring was to achieve lower cost and consequently higher profitability. The paradigm of such approach was then changed to focus more on the value chain through industrial upgrading.

Industrial upgrading can be described as the approach to be followed by the players of the value chain process to switch their activities from low value activities to higher value activities within the global production network. The upgrading also includes governmental policies, institutions, corporate strategies, technologies and labors. The process of industrial upgrading is considered to be an efficient economic progression that all players within the economic system improved their performance and capabilities. In-addition to the added value for multinational corporates in-terms of profitability and their ability to focus more on their core competencies by diversifying its operations, a series of benefits is gained by developing countries by expanding their capabilities in-terms of manufacturing, knowledge and even technology.

For emerging markets this is considered to be the optimum approach to be followed as to access the global production network as this facilitates the transfer of knowledge and technology and even capital. The industrial upgrading creates a strong strategic network across the value chain allowing all players to adapt easily to any market or industry change, especially in industries that technology is considered as a factor of competition. A clear example of the progression of the industrial upgrading that leads developing countries not only to increase its exports of low technology products to developed countries to even the high technology products, is the China experience (Gereffi, G., 2011).

There are four types of upgrading (Humphrey, J & Schmitz, H., 2002; Tejada, P., 2010):

- Product upgrading: elevating the value added for products by creating more refined ones.
- Process upgrading: developing a new production or processing operations to develop their products either through advanced technology or by reorganizing its production system.
- Intra-chain / Functional upgrading: switching functions as to elevate the value added by activities by acquiring, abandoning or moving activities.
- Inter-chain upgrading: when constellation firms use its own competency in one sector or section to move to productive activity.

**The Governance of Value Chain and Upgrading**

Gereffi (1999) emphasized the connection between governance and upgrading by promoting the link between the implementation of governance within the GVA and the endorsement on process, product and functional upgrading of small local producers. The perspective adopted by Gereffi emphasizes that the interaction between local producers and global buyers will enhance their production process leading to improving their design, marketing and other services capabilities. On the other hand there were concerns regarding the upgrading of local producers within the GVC. Researchers mainly agreed on the upgrading opportunities for local producers to achieve as to be a part of the GVA in-terms of access to information about the required competencies and standards required. However, the upgrading opportunities are limited to product and process upgrading (Tejada, P, Francisco J., S., and Joaquı´n, G., 2010).

Along with such perspective Humphrey and Schmitz (2002) offered the idea that chain coordination varies with upgrading opportunities. They also concluded that the quasi-hierarchical governance facilitates process and product upgrading but its limited achievement could be attained in-terms of functional upgrading.

**The Solar Energy Value Chain**

The solar energy value chain is divided into two essential segments, the first is the product and the other is the service. This spectrum ranges from manufacturing of devices and equipment, all the way to installation and maintenance. The primary components of the product manufacturing process are poly-silicon, wafers, cells, modules, mounting and tracking systems and electrical components. While the services include project development, distribution, engineering, construction and maintenance. Figure 1 illustrates the main phases of the solar energy value chain.

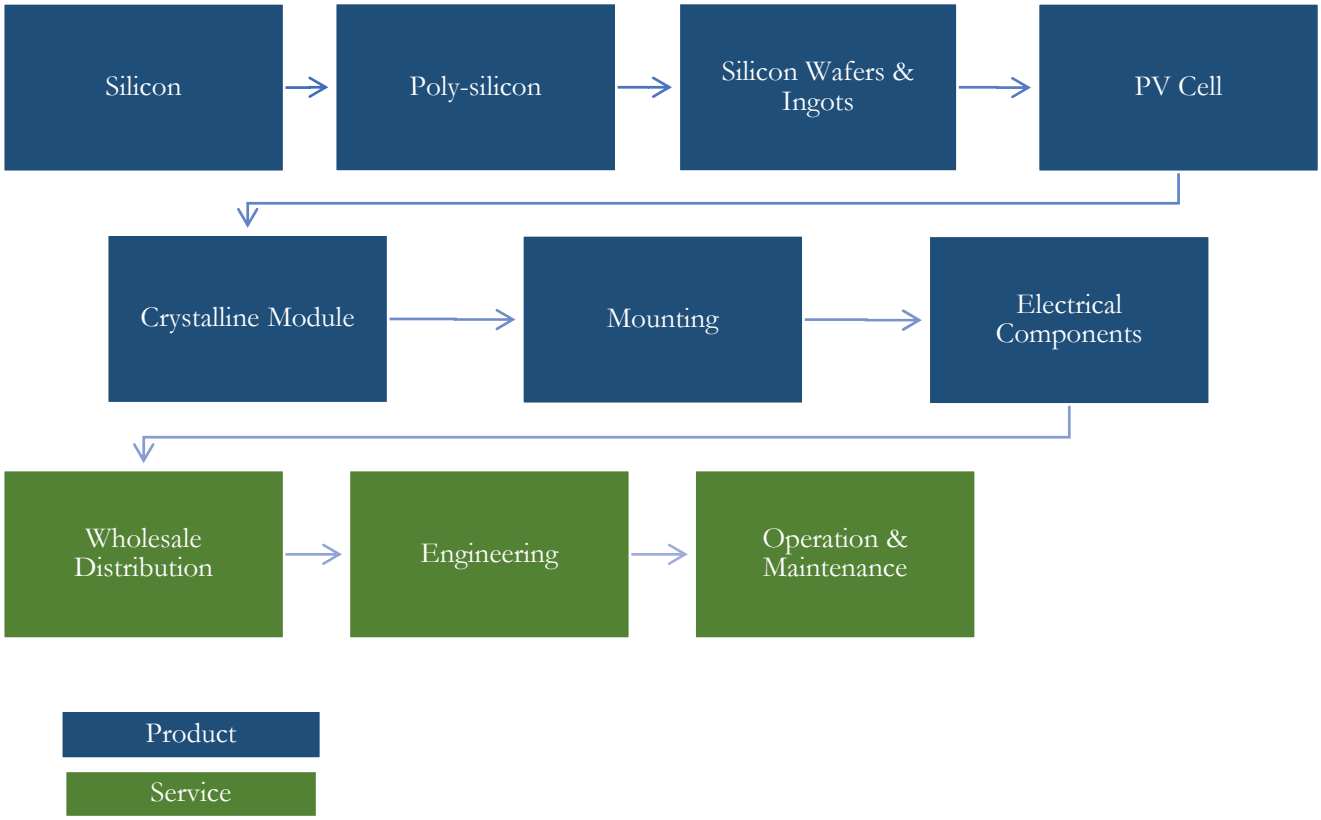


*Figure 1. Solar Energy Value Chain*

The manufacturing process starts by transforming the silicon that it is extracted from sand to poly-silicon, then processing it to be wafers, consequently these wafers are further processed to make solar cells (PV cell). Solar cells are merged into larger units – the panels – in panel-assembly production. The result of such process is solar panel, or module, which generates electricity and it consists of many solar cells, with weather protection (glass), embedding and framing. Then the module is then assembled with another electrical devices wires, batteries for storing electricity, inverter to convert the direct current produced by panels to alternative current

as to feed the public power grid. These are the main devices to be connected to the module, depending on the application required. Then this system is supplied to fit the required application through direct distributers or engineering, followed by that is the installation and the final phase is maintenance.

A key success factor of solar value chain is vertical integration or a strong and reliable partnership between all players. Most multinationals who are specialized only in solar energy adopt the concept of vertical integration. These organizations own all the manufacturing operations and act as fully integrated manufacturers not only to ensure the quality control over its' products and procedures but also the ability to control to ramp up production to fit its' needs in case in change in technology. Moreover this fully integrated manufacturing system allow not only the use of all the production stages to be used with the organization but also it allows them to be in the supply chain of another organizations that do not follow the same strategy, allowing them to be a lead player within the value chain of the solar energy industry. Nerveless some not only supply a fully integrated solar system but also even supply the auxiliaries required for installation like bolts, nut and conduit and also installing diagrams and catalogs. Following such structure eliminates the need for distributors and allow a direct relationship between the engineering firms and the manufacturer (Green Rhino Energy, 2014) as reported on Green Rhino Energy (2013); (svmi, 2014) as reported om SVMI; (firstsolar, 2014) as reported on First Solar; (solarworld-usa, 2014) as reported on Solar World.

## THEORETICAL FRAMEWORK

The theory of GVC helps in identifying the governance structure, the lead players and the degree of power distribution along the value chain of the solar energy industry. Figure 3.1 illustrates the five types of value chain governance structure(s) and the inter-relation in-terms of power and coordination between suppliers and customers (Gereffi, G., 2011). However, such descriptive typology of governance structure is considered the preliminary approach as to interpret the heterogeneous relationship between all economic parties, but it cannot predict the change in governance pattern, either by the maturity of the industry itself or by actions performed by key players (Gereffi, G., Humphrey, J. & Sturgeon, T., 2005).

Subsequently identifying and studying the three determinants that affect the dynamic of the governance pattern; complexity of transactions, ability to codify transactions and suppliers' capabilities. By adopting such approach it is considered as an acknowledge of the problem of asset specificity raised by the transaction cost economics, but also prominence to the issue raised by the same approach termed 'mundane' transaction cost, which is the cost associated of the synchronizing along the chain. It is debated that the cost of coordination 'transaction cost', 'mundane' is proportional with the product standardization, integration of product architectures and products/services with time sensitivity (Baldwin, C., and Clark, K., 2000). Table 1 describes the contributing factors (independent variables); complexity of transactions, ability to codify transactions and suppliers' capabilities, that any change in one of them leads to a change in the governance pattern (dependent variables) but such shift is predictable (Gereffi, G., 2011). Such transferal can be mediated by the key players in the chain, as it could be lead firms or governments.

*Table 1. Dynamics in Global Value Chain Governance*

| Governance type | Complexity of transactions | Ability to codify transactions | Suppliers' capabilities |
|---|---|---|---|
| Market | Low | High | High |
| Modular | High | High | High |
| Relational | High | Low | High |
| Captive | High | High | Low |
| Hierarchy | High | Low | Low |

SOURCE: Gereffi, Humphrey & Sturgeon, 2005

Based on the proposed framework by Gereffi, Humphrey and Sturgeon (2005), and to Gereffi (20110 and the type of governance relationship within each governance structure, as well as the governance relationship proposed by Humphrey and Schmitz (2002), Figure 2 demonstrates the link between both governance relationship and governance structure.

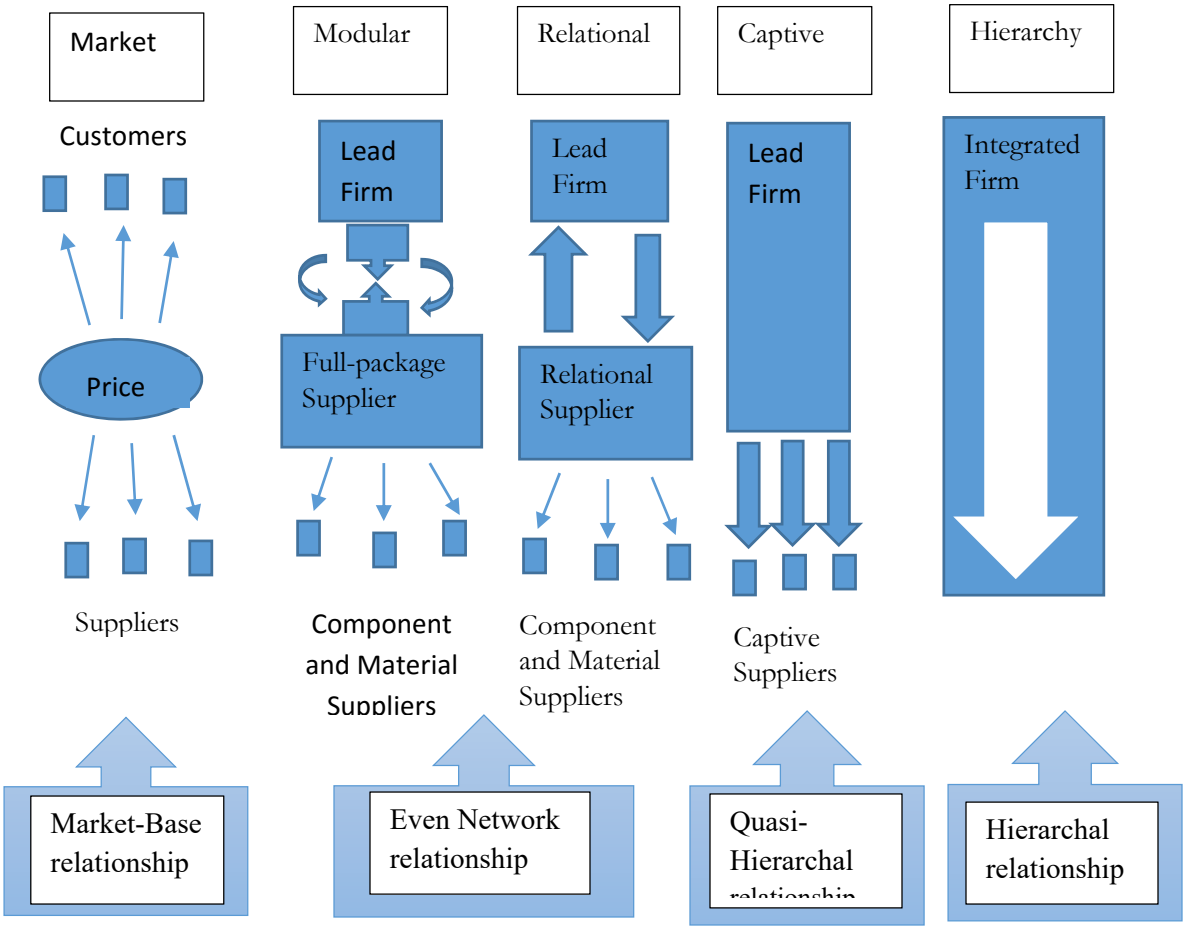


*Figure 2. Governance Relationship and Governance Structure*

**Research Propositions**

**P1:** Complexity of transactions influence the governance structure type and governance relationship.
**P2:** Information codification influence the governance structure type and governance relationship.
**P3:** Suppliers' capabilities influence the governance structure type and governance relationship.
**P4:** Market-based relationship supports upgrading functional upgrading within the solar energy value chain.
**P5:** Even network relationship supports all types of upgrading within the solar energy value chain.
**P6:** Quasi-hierarchical relationship supports product and process upgrading the within the solar energy value chain.

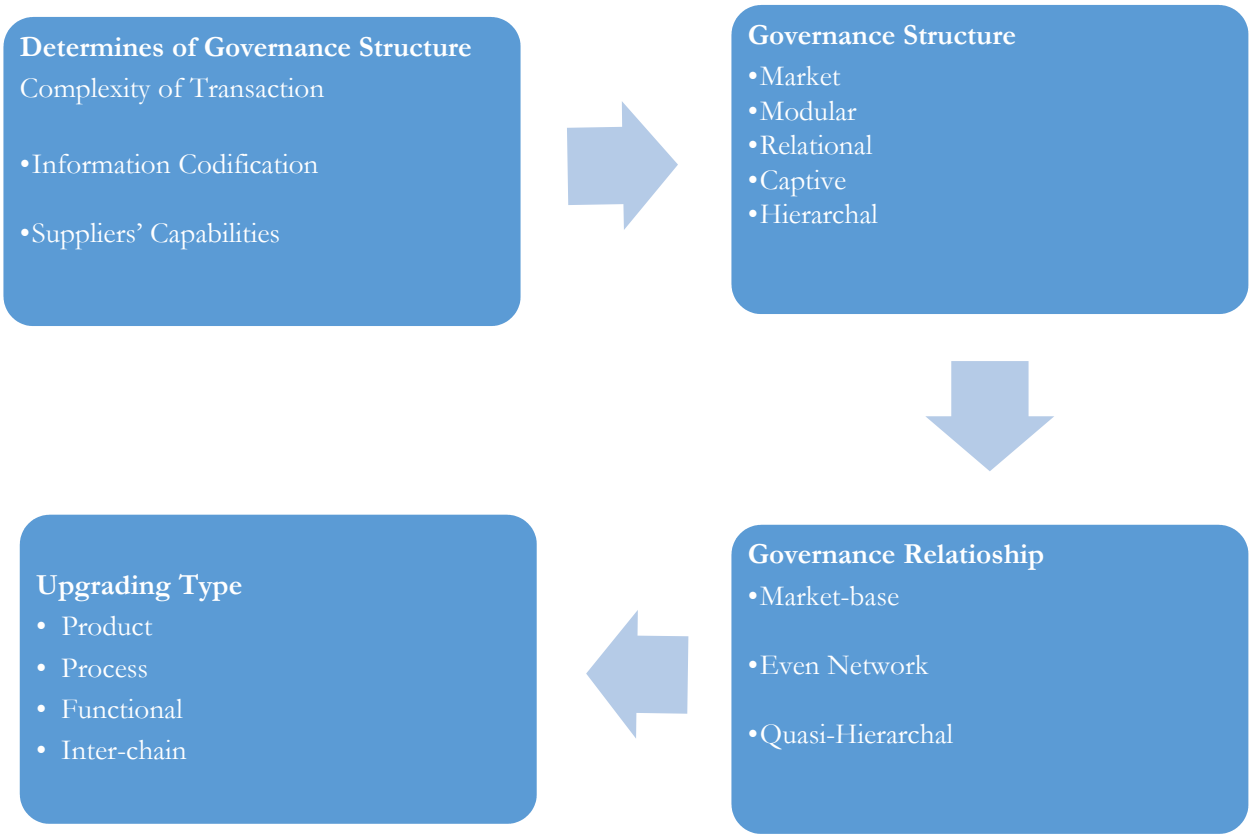


*Figure 3. Theoretical Framework*

**Preliminary Analysis**

Preliminary analysis show the outcome form testing the previous propositions with the associated independent variables, indicates that the solar energy value chain cannot be addressed with one governance structure. As indicated in figure 4, the solar energy value chain is

segregated into three different types of governance structure. The upstream of the industry that is starts from extraction of silicon from sand reaching to the phase of mounting is considered a hierarchal structure with a high complex transactions, with very low ability to codify such transactions and lack of high capable suppliers to be able to rely on.

The other type of governance structure that participate in the solar energy value chain is a relational structure, which represents the governance pattern linking the electrical component producer which is the inverter producer with the PV overall producer (until the mounting phase). Where both players interact with a complex transactions, with a low ability to codify such procedures but both represents a very high capable suppliers.

Finally the governance structure that represents the pattern between the local service firms with the whole industry is considered a market governance structure. That is characterized by low complex transactions that is easy to codify and the suppliers' base is considered highly qualified in-terms of performance.

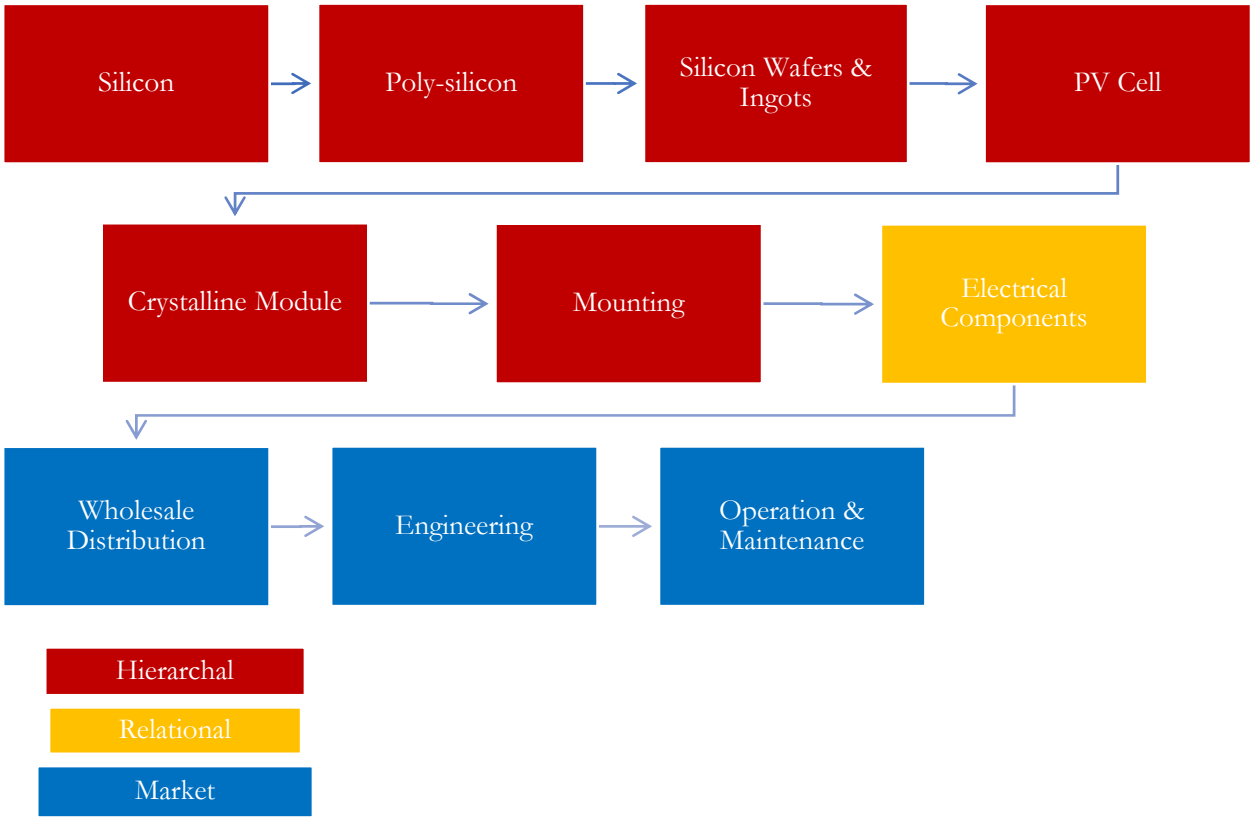


*Figure 4. The governance structures in solar energy value chain*

The data also prevailed that even the new entrants for the solar energy industry are aiming to penetrate the industry through the service phase and that they are considering to modify their organizational structure of their existing firms in-terms to upgrade their performance to cope with the new business they are penetrating. Figure 4.2 shows the

combination and interrelation between the independent and moderating variables that supports the outcome that the preferred the type of upgrading in the market-base relationship is functional upgrading.

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