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Abstract:

Organizations are exposed to ever-increasing dynamic environments, making sustaining the derivation of IT benefits critical. However, researchers have observed that IT benefits are short-lived and have called for studies on how organizations can sustain the derivation of IT benefits, especially in dynamic environments. Research shows that the integration of IT assets and other organizational resources needed to form IT-enabled resources from which organizations derive IT benefits can also constrain the renewal of IT-enabled resources to sustain the derivation of IT benefits. In this study, we draw on relevant theories, published empirical cases, and a primary case study to explore, from a structural perspective, the renewal of IT-enabled resources to sustain the derivation of IT benefits. We find that certain structural properties (i.e., component flexibility, component centrality, and component coupling) emerge during the formation and modification of IT-enabled resources and influence the renewal of IT-enabled resources. We extend Nevo and Wade's model on the formation of IT-enabled resources with the structural properties and offer eight propositions on how the structural properties and organizational capabilities influence the renewal of IT-enabled resources. We discuss the theoretical and managerial implications and identify areas for future research.

Keywords: IT Benefits, Business Value of IT, Synergy, IT-Enabled Resources, Loose Coupling, Component Flexibility, Component Coupling, Component Centrality, Renewal, General Systems Theory, Social Network Theory.

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1 Introduction

IT benefits, which are the performance impact of IT at the individual, process, and organizational levels (Chan, 2000; Melville et al., 2004), are at the core of Information Systems (IS) research. Conclusions from several studies (e.g., Nevo & Wade, 2010; Wade & Hulland, 2004), including meta-analyses (e.g., Sabherwal & Jeyaraj, 2015), point to the fact that an IT asset, by itself, rarely results in IT benefits. The formation of complementarity or synergy between IT assets and other organization resources has long been identified as an avenue to derive IT benefits (Wade & Hulland, 2004; Melville et al., 2004; Piccoli & Ives, 2005; Kohli & Grover, 2008; Seddon, 2014). For example, Nevo and Wade (2011, 2010) suggest that when an IT asset and an organizational resource are *synergistically* combined an IT-enabled resource is formed and that the IT-enabled resource has *synergy* (i.e., a positive emergent capability) that provides the IT-enabled resource with the ability to achieve organizational tasks and goals, thus resulting in IT benefits.

Similarly, an executive of Walmart, the number one company on the list of Fortune 500 companies for the year 2017, stated, "It's important to look at not just the technology but what it enables…what does it enable in terms of merchandising and logistics that maybe wasn't possible before?" (Nusca, 2017). The complementarity view hinges on the integration and compatibility of the IT assets and organizational resources (Nevo & Wade, 2010; Seddon, 2014; Wade & Hulland, 2004). Indeed, research has shown that high integration and compatibility of IT assets and organizational resources results in IT benefits including strategic and operational benefits (e.g., Nevo & Wade, 2011).

Nevertheless, research has also found that integrating IT assets and organizational resources can constrain the ability of an organization to reconfigure and redeploy the IT assets and organizational resources to meet new organizational goals (Saraf et al., 2013; Soh & Setia, 2022; Tanriverdi & Du, 2020), thus constraining the derivation of IT benefits in new and changing organizational environments. IS researchers have noted that IT benefits derived from IT assets are short-lived, especially in dynamic environments (Kohli & Grover, 2008; Wade & Hulland, 2004). Likewise, in the strategic management literature, research has shown that resources (e.g., IT-enabled resources) whose value depends on complementarities or synergy are particularly vulnerable to environmental turbulence that disrupts synergy (Le Breton-Miller & Miller, 2015). It is apparent that the factors (e.g., resource integration and combinations), needed to create complementarities or synergies have paradoxical effects; they enable the formation of synergy to meet current organizational goals but constrain the *renewal* of synergy to address new organizational goals.

Research suggests that, for organizations to survive in dynamic environments, they need to retain the ability to reconfigure their resources to create "shifting synergies" needed to address changing organizational strategic imperatives (Eisenhardt & Martin, 2000, p. 1107). The inability of even established organizations to reconfigure and redeploy their resources and capabilities to address new strategic imperatives can lead to failure (e.g. bankruptcy (Thornhill & Amit, 2003)). This makes research on sustaining the derivation of IT benefits an important research theme in IS research. Nevo and Wade (2011) have called for an in-depth study on how organizations renew and sustain synergy. Several other researchers (e.g. Kohli & Grover, 2008; Schryen, 2013; Wade & Hulland, 2004) have also called for further research into how organizations can sustain the derivation of IT benefits, especially in dynamic environments.

In response, some researchers have studied the role of organizational capabilities, for example, strategic flexibility (Chen et al., 2017; Pavlou & El Sawy, 2010) and IT integration capability (Benitez et al., 2018), in reconfiguring IT-enabled resources to address changing strategic demands. Others have also studied the effects that the properties of an IT asset or infrastructure, for example, infrastructure malleability (Henfridsson & Bygstad, 2013), and IT infrastructure flexibility (Benitez et al., 2018), have on the reconfiguration of IT assets to address new challenges.

However, there is a paucity of research on the structural properties of an IT-enabled resource and on how the structural properties evolve during the formation or modification of the IT-enabled resources to enable or constrain the renewal and redeployment of the IT-enabled resource. This study draws on general systems theory (Ackoff, 1971; Kast & Rosenzweig, 1972), loose coupling theory (Orton & Weick, 1990; Perrow, 2011), social network theory (Freeman, 1978; Friedkin, 1991), and on a review of 18 published empirical cases on post-implementation changes and on an in-depth case study to answer the research question:

What are the structural properties of IT-enabled resources, and how do the structural properties enable or constrain the renewal of IT-enabled resources to sustain the derivation of IT benefits?

The study makes three key theoretical contributions. Firstly, it identifies three structural properties of an IT-enabled resource namely component flexibility, component centrality, and component coupling, and extends Nevo and Wade's (2011, 2010) model on the formation of IT-enabled resources with the structural properties that influence the renewal of IT-enabled resources. Secondly, it shows that the three structural properties individually enable or constrain the renewal of an IT-enabled resource. Further, whereas component centrality moderates the influence of component flexibility on the renewal of IT-enabled resources, component coupling moderates the influence of component centrality and component flexibility on the renewal of IT-enabled resources. Thirdly, based on the narratives from 18 published cases, and one primary case study, this study contributes eight propositions that relate the structural properties and organizational capability to the renewal of IT-enabled resources to sustain the derivation of IT benefits. The contributions complement the organizational capability view on the renewal of resources in that they explicate the structural properties of resources that determine the extent to which resources can yield themselves to renewal.

With the emerging demands for new resource combinations (e.g., in pursuance of digital transformation and digitalization), managers can leverage our findings on the three structural properties to guide the formation and renewal of IT-enabled resources and the creation of "shifting synergies" needed to address shifting organizational goals, especially in dynamic environments (Eisenhardt & Martin, 2000, p. 1107). Further, our findings suggest that managers should invest not only in capabilities that enable the formation of IT-enabled resources but also in capabilities that endow IT-enabled resources with the structural properties that enable their renewal to sustain the derivation of IT benefits.

2 Background Literature

In this section, we briefly review the literature on the derivation of IT benefits and introduce the theories that we leverage (i.e., general systems theory, social network theory, and loose coupling theories) in conceptualizing the structural properties of IT-enabled resources. Then, we extend Nevo and Wade's (2011, 2010) conception of IT-enabled resources with the structural properties and define the scope of the study.

2.1 Derivation of IT Benefits

IT benefits can be defined as "the organizational performance impacts of information technology at both the intermediate process level and the organization-wide level, and comprising both efficiency impacts and competitive impacts" (Melville et al., 2004, p. 287). How and the extent to which organizations generate IT benefits at the process level and organization level are influenced by several factors (Melville et al., 2004). Drawing on the resource-based view of the firm (see Barney, 1991; Barney et al., 2001), Melville et al (2004) provide an integrative model for IT benefit research that groups these factors into macro-environment factors (e.g., country characteristics), competitive environment factors (e.g., industry characteristics, and effect of trading partners), and organization level factors (e.g., IT resources and complementary organizational resources). IT resources consist of technological IT resources (e.g., IT infrastructure and business applications) and Human IT resources (e.g., technical skills and managerial skills). Based on Wade and Hulland (2004)'s definitions of resource[1] and assets[2], we refer to technological IT resources as IT assets. This study focuses on the derivation of IT benefits from IT assets (see also Nevo and Wade (2011, 2010)).

IT assets are commodity-like and may result in IT benefits only when they are synergistically combined with other organizational resources (or complementary resources) such as processes, departments, and teams to form new resources called IT-enabled resources (Nevo & Wade, 2011, 2010), for example, digital business capabilities (Kohli & Grover, 2008) and business analytics-enabled customer relationship management processes (Someh et al., 2019). These new resources (i.e., IT-enabled resources) do

[1] Wade and Hulland (2004) define resources as "assets and capabilities that are available and useful in detecting and responding to market opportunities or threat" (p. 109)
[2] Wade and Hulland (2004) define assets as "anything tangible or intangible the firm can use in its processes for creating, producing, and/or offering its products (goods or services) to a mark" (p. 109)

possess emergent capabilities which are "either new capabilities that are possessed by neither the IT asset nor the organizational resource in isolation, or existing capabilities with previously unattainable values" (Nevo & Wade, 2011, p. 405). Positive emergent capabilities are referred to as synergy, which provides the IT-enabled resource with the ability to achieve organizational tasks and goals, thus resulting in IT benefit. For instance, synergistically combining an IT asset and a customer relationship management unit can produce an IT-enabled customer relation management unit that has new capabilities to influence operational and strategic performance (Nevo & Wade, 2011). Also, see Someh et al. (2019) for how an organization derived IT benefit from business analytics by synergistically combining business analytics and other organizational resources.

Because IT-enabled resources, rather than IT assets, are the unit for deriving IT benefits, organizations and users engage in efforts to integrate IT assets and other organizational resources to form IT-enabled resources. However, research has also shown that the integration needed to form IT-enabled resources from which organizations and users derive IT benefits also constrains the renewal of IT-enabled resources in pursuit of emerging goals thus derailing the derivation of IT benefits, especially in dynamic environments (Nan & Tanriverdi, 2017; Saraf et al., 2013; Wade & Hulland, 2004). In other words, integration leads to the formation of synergy but can also impede the renewal of synergy. Further, in the strategic management literature, research shows that the alignments needed to create synergy make resources whose value depends on complementarity or synergy particularly vulnerable to environmental disruptions because of the high likelihood that their synergy will be disrupted by misalignments (Le Breton-Miller & Miller, 2015).

Organizational performance (e.g., competitive advantage), especially in dynamic environments, is temporal, and a firm can approach sustained competitive advantage by gaining a series of temporary competitive advantages or successive competitive advantages (Sirmon et al., 2010, 2011). In that regard, organizations need to continually innovate and reconfigure their resources to address changes in the environment and goals of the organization (Eisenhardt & Martin, 2000; Helfat & Peteraf, 2003; Kettinger et al., 1994; Sirmon et al., 2011; Wade & Hulland, 2004). One such resource is the IT-enabled resource (Nevo & Wade, 2011; Someh et al., 2019). IS research on IT benefit has also shown that factors such as environmental turbulence and ambivalence can derail synergy making IT benefit short-lived (Wade & Hulland, 2004). Therefore, to sustain the derivation of benefits from resources whose value depends on synergy, organizations need to continually reconfigure or renew the resources to create new synergies or "shifting synergies" with which they can attain emerging goals (Eisenhardt & Martin, 2000, p. 1107).

2.2 Dynamic Capabilities and Structural Perspectives on Resource Renewal

The dynamic capabilities perspective is a dominant view of how organizations sustain performance outcomes, including competitive advantage, in dynamic environments (Kim et al., 2011; Tallon, 2008; Winter, 2003). Dynamic capabilities are higher-order organizational routines or processes that are employed to renew, extend, reconfigure, and redeploy lower-order organizational capabilities and resources (Drnevich & Kriauciunas, 2011; Winter, 2003; Teece et al., 1997; Eisenhardt & Martin, 2000). In the IS literature, several forms of dynamic capabilities have been studied, namely, IT capability (Bharadwaj, 2000), improvisational capability (Pavlou & El Sawy, 2010), strategic flexibility (Chen et al., 2017; Pavlou & El Sawy, 2010), IT integration capability (Benitez et al., 2018), IT reconfiguration capability (Pavlou & El Sawy, 2010; Rai & Tang, 2010), IT application orchestration capability (Queiroz et al., 2018), IT-enabled dynamic capabilities (Mikalef et al., 2021) and dynamic IT capabilities (Li & Chan, 2019). Eisenhardt and Martin (2000) suggest that the long-term competitive advantage of an organization lies in resource configuration, not in dynamic capabilities per se. There is ample empirical evidence that demonstrates the effects of these capabilities on planned and improvisational reconfiguration and renewal of resources to address shifting organizational imperatives. For instance, organizations with IT application orchestration capabilities can renew their IT application portfolios (Queiroz et al., 2018), and organizations with improvisational capabilities can spontaneously renew their resources in highly turbulent environments (Pavlou & El Sawy, 2010). In essence, the dynamic capabilities perspective suggests that organizations are able to renew their resources when they have the capability to do so.

The structural perspective on resource renewal suggests that the structural properties of resources can enable or constrain an organization's ability to renew, reconfigure, and redeploy its resource base (Le Breton-Miller & Miller, 2015; Sirmon et al., 2008). In other words, the structural properties of resources can aid or curtail the effects of dynamic capabilities. Structural properties refer to the nature and arrangement of, and interactions among, the components that make up a resource (e.g., IT-enabled resources).

Structural properties can support the creation and effects of dynamic capabilities. Kim et al. (2011) found that IT infrastructure flexibility improves process-oriented dynamic capabilities, which is the ability of an organization to change its business processes. Similarly, Tallon and Pinsonneault (2011) found that IT infrastructure flexibility directly supports organizational agility, which is the ability of the organization to change in response to its environment. Further, Benitez et al. (2018) found that IT infrastructure flexibility influences both business flexibility and the ability of an organization to integrate its IT resources after a merger and acquisition. Recently, Mikalef et al. (2021) found that IT flexibility leads to the development of IT-enabled dynamic capabilities that are "a firm's abilities to leverage its IT resources and IT competencies, in combination with other organizational resources and capabilities, to address rapidly changing business environments" (2021, p. 516).

Conversely, the structural properties of a resource can have negative effects on resource renewal. Inflexible legacy IT can constrain managerial efforts at renewing and redeploying the IT together with business processes to achieve new goals. Research shows that when even flexible IT assets are tightly integrated with other resources, the flexibility of the IT assets can be derailed making the resource combination difficult to renew in pursuit of new goals (Lu & Ramamurthy, 2011; Seethamraju, 2009). Sirmon (2008) found that resources whose structures make it difficult for them to be renewed and deployed (i.e., resources with low redeployability) can limit managerial capabilities in redeploying them to address new goals. That is, managers can only renew and redeploy resources to the extent allowable by the structural properties of the resources. The recent drift towards connectedness (e.g., using inter-organizational and cloud-based resources), calls for particular attention to the structural properties of resources (Chen et al., 2021; Flak et al., 2022; Schneider et al., 2018). Therefore, though we acknowledge the importance of organizational capabilities, especially dynamic capabilities, regarding the renewal and redeployment of resources; in this study, we shift our attention more to the structural properties of IT-enabled resources and how they influence resource renewal. From the discussions thus far, it should be noted that these two views do complement, rather than oppose, each other in explaining the renewal and redeployment of organizational resources to address shifting goals. Whereas dynamic capabilities highlight the organizational ability to renew its resources, structural properties highlight the extent to which resources can yield themselves to renewal efforts.

2.3 Conceptualizing the Structural Properties of IT-enabled Resources

Several research findings point to the structural properties of IT-related resources. Mostly, concepts such as flexibility (Tallon & Pinsonneault, 2011) and modularity (Chung et al., 2003) are used to denote the structural properties of IT that make it possible for the IT to be changed, extended, or renewed to address emerging organizational goals. However, research has mostly studied these concepts in relation to IT assets. Seeing that IT-enabled resources, rather than IT assets, are the generators of IT benefits, we explore the structural properties that emerge when IT assets are combined with other organizational resources to form IT-enabled resources.

To do so, we adopt Nevo and Wade (2010,2011)'s conception of IT-enabled resources and concentrate on the systems theory end of the model to explore the structural properties of IT-enabled resources. We draw on general systems theory (Ackoff, 1971; Kast & Rosenzweig, 1972), loose coupling theory (Orton & Weick, 1990; Perrow, 2011), and social network theory (Freeman, 1978; Friedkin, 1991) to understand the nature of the internal structures of IT-enabled resources that can affect the renewal of IT-enabled resources to address shifting goals. These theories were not arbitrarily chosen; we chose them based on a review of published cases on post-implementation changes (Lumor, 2019) which we will discuss later in section four (also see Table A1 in Appendix A).

The three theories complement each other in conceptualizing the structural properties of IT-enabled resources. General systems theory highlights the composition (i.e., components) of IT-enabled resources and the existence of interactions that lead to the formation of synergy among the components. However, it does not explicate the number and nature of links along which such interactions happen. Loose coupling theory complements general systems theory in that, it explicates the nature and number of links between any two components and their implication for the efficiency (e.g., synergy) and effectiveness (e.g., ability to change) of the component combination. However, from the published cases we reviewed (See Table A1 in Appendix A), hardly does IT-enabled resources consist of only two components. We, therefore, draw on social network theory to understand how several components are linked together in a network and the implications for the network positions of the components for synergy formation and the ability to change. That is, whereas loose coupling theory looks at the type and number of links between two components,

social network theory explores the number of links between a focal component and other components within a network. Thus, the three theories together provide a comprehensive theoretical base to conceptualize the structural properties of IT-enabled resources. We briefly discuss each of the theories in the subsections that follow.

2.3.1 General Systems Theory

A system consists of at least two elements or components that are interconnected and react with each other (Ackoff, 1971; Kast & Rosenzweig, 1972). Without the interconnection and reaction, there is no system (Ackoff, 1971). In essence, each component of a system should be connected to and interact with at least one other component of the system (Ackoff, 1971). Though each component of a system may have its own role or function and can be a system on its own (i.e., a subsystem), the total function of the whole system is of interest to system theorists. A holistic view of systems suggests that a system is more than the sum of its parts (Ackoff, 1971; Kast & Rosenzweig, 1972). That is, as parts interact, they do so in ways that synergistically enhance the abilities of each part or form composite abilities that are more than the abilities of the individual components put together (Ackoff, 1971).

Systems can be closed or open, and static or dynamic (Ackoff, 1971; Kast & Rosenzweig, 1972). A closed system has an impermeable boundary that shields the internal operations of the system from the system's environment (Ackoff, 1971; Kast & Rosenzweig, 1972). An open system on the other hand has a permeable boundary that allows the system to exchange resources with influence and be influenced by its environment (Ackoff, 1971; Kast & Rosenzweig, 1972). Organizations (or firms) and their components (e.g., resources) typify open systems (Kast & Rosenzweig, 1972). Resources (e.g., IT-enabled resources) that are formed from the combination of other resources can have synergy when their components are themselves open systems that allow interactions across their boundaries (Ackoff, 1971; Chatterjee et al., 2021). Without such interactions across permeable boundaries, there will be no synergy nor changes (i.e., reactions, and responses) in one component in relation to the other. A static system is a system in which no event occurs and therefore "displays no change of structural properties" or state (Ackoff, 1971, p. 663). A dynamic system is a system in which events occur and whose state changes over time (Ackoff, 1971; Kast & Rosenzweig, 1972). Dynamic systems change in pursuit of an outcome (e.g., maintaining a state, and seeking a goal or multiple goals) or in being purposeful (Ackoff, 1971). That is, dynamic systems change in response to their external or internal environments to produce an existing outcome or to craft and pursue a new outcome via existing or new means.

Organizations are purposeful in the exploration and exploitation of at least some of their resources, including IT-enabled resources (O Reilly & Tushman, 2004; Scott & Davis, 2016; Sirmon et al., 2011). To allow organizations to do so, IT-enabled resources should be open and dynamic systems capable of adapting to different conditions to remain relevant in attaining shifting organizational goals. Each component of an IT-enabled resource must thus be adaptable or be able to change itself or induce change in its environment to attain existing or new organizational goals. The extent of change will, however, depend on the goal, the potential, and the structural properties of the IT-enabled resource. When the current potential or synergy of the IT-enabled resource can attain the new goal, little changes may be needed. The change will get more prominent as the new goal goes beyond the current potential of the IT-enabled resource. For instance, consider an IT-enabled teaching process, for example, a synergistic combination of an IT asset (e.g., Zoom or Teams) and teaching processes, that can host 200 students. If the new goal is to host less than 200 students, there may be no apparent changes needed. However, if the new goal is to host more than 200 students, then the components of the IT-enabled teaching processes will have to change to meet the new goal. The components of an IT-enable resource include IT assets and other resources (e.g., processes, departments, and teams (Nevo & Wade, 2011, 2010)).

Renewal of an IT-enabled resource to address current or new goals will therefore require changes to IT assets and other resources (Baird et al., 2017; Leonardi, 2011; McGann & Lyytinen, 2008; Nevo et al., 2016; Orlikowski, 1996; Robey et al., 2002). We refer to the extent to which the individual components of an IT-enabled resource can change to attain existing or new goals as *component flexibility*.

2.3.2 Loose Coupling Theory

According to loose coupling theory (Orton & Weick, 1990; Perrow, 2011), the type of coupling describes the number and strength of connections or interdependencies among the components that form a resource combination (e.g., an IT-enabled resource). When the components are closely connected such

that they are indistinctive yet responsive to each other but not to external forces, the components are tightly coupled (Orton & Weick, 1990). Tightly coupled components have less variance (e.g., in routines and use of resources), and thus support efficiency (Berente et al., 2008; Perrow, 2011). However, tightly coupled components can pose high constraints when management needs to separate, that is decouple, reconfigure, and redeploy the components in a different context (e.g. in pursuit of a new strategic goal) (Orton & Weick, 1990; Perrow, 2011; Tanriverdi & Du, 2020). Thus, though tightly coupled resources generally lead to efficiency (Berente et al., 2008), they can also hamper autonomy, agility, and effectiveness (Berente et al., 2008; Marabelli & Newell, 2010; Perrow, 2011).

Components that are loosely connected such that they retain their distinctiveness, and are not responsive to each other, are said to be coupled (Orton & Weick, 1990). A case in point is the actions of project managers who obtained data from an ERP via a business warehouse and locally processed the data using a spreadsheet to meet their project budgeting needs (Berente et al., 2016). Because coupled components have weak interdependencies and are not responsive to each other, the components may evolve indiscriminately. Thus, coupled components enable change and can lead to optimizing individual components at the expense of optimizing the IT-enabled resource as a whole (Orton & Weick, 1990).

When components are both tightly and loosely connected such that they retain their distinctiveness, and yet are responsive to each other and external forces, the components are said to be loosely coupled (Orton & Weick, 1990). In other words, components that are loosely coupled have tight links and loose links between them. Loose coupling is thus not the absence of tight links but the existence of both tight and loose links between any two components (Berente et al., 2008; Perrow, 2011). For example, though institutionally, departments in a university may be loosely connected and independent of each other, individuals from different departments may form tight relationships (Rubin, 1979). Loosely coupled components handle external changes either by neutralizing or assimilating the changes (Orton & Weick, 1990). The tight links provide stability or persistence, whereas the loose links provide a buffer to neutralize the changes and also provide the opportunity for experimentation, learning, and adaptation to assimilate the changes (Orton & Weick, 1990). Loosely coupled components are thus more open to changes than tightly coupled components are (Scott & Davis, 2016, p. 86). Loosely coupled components may thus lead to stability, flexibility, effectiveness, autonomy, and resilience to risk (Berente et al., 2008; Marabelli & Newell, 2010; Orton & Weick, 1990; Perrow, 2011).

It is worth noting that generally there is no one type of coupling that is preferable for all component combinations (Berente et al., 2008; Perrow, 2011). Besides, multiple types of coupling can exist among the components of an IT-enabled resource (Scott & Davis, 2016, p. 94). For instance, a digital platform can have a stable core, consisting of tightly coupled components, that is controlled by a platform owner, and a dynamic interface that allows several actors to contribute modular components (e.g., plugins and APIs) that are loosely coupled to form platform services (Cusumano, 2010; de Reuver et al., 2018; Gawer & Cusumano, 2008, 2014).

The types of coupling that exist among the components of IT-enabled resources influence the renewal of the IT-enabled resources by enabling or constraining the rearrangement or reconfiguration of their components. We refer to this structural property as component coupling which we define as *the number and strength of interdependencies or links that exist among the components of IT-enabled resources*.

2.3.3 Social Network Theory

Social network theory explains the influence and gains of a focal actor within a network of actors in terms of the actor's links to other actors within the network (Freeman, 1978; Friedkin, 1991). A network consists of actors (represented as nodes) and ties (represented as links) between the actors (Borgatti & Ofem, 2010; Liu et al., 2017). Apart from its use in studying the effects of social actors in social networks (e.g., advice-giving and advice-seeking networks (Sykes et al., 2009)), the social network theory, especially the concept of *centrality*, has been applied in several other contexts. For example, it has been used to study organizational performance within inter-organizational networks (Ferriani & MacMillan, 2017; Hoffman et al., 1990; Williams, 2005), open-source software development processes (Madey et al., 2002), the vulnerability of components in cyber-physical systems (Umunnakwe et al., 2021), and electrical power transmission systems (Cadini et al., 2008). Generally, the centrality of a unit (or a component) refers to "its summed connections to others" (Bonacich, 1987, p. 1172). A component that is connected to several other units or components has high centrality, whereas a component that is connected to a few other units or components has low centrality. The extent of centrality is a spectrum and can have several forms of measures depending on the focus of a study (Freeman, 1978; Landherr et al., 2010).

Centrality is usually associated with positive effects. High centrality can lead to influence (Burkhardt & Brass, 1990; Sykes et al., 2009), improved access to information (Vardaman et al., 2012), resource leveraging (e.g., Kohli & Devaraj, 2004; Tanriverdi, 2006), and organizational performance (Ferriani & MacMillan, 2017). However, centrality can also have negative implications. For instance, the high centrality of a component may increase the risk and vulnerability associated with the component (Cadini et al., 2008; Umunnakwe et al., 2021). Organizations with high centrality may also experience a decline in performance because of the cognitive cost of maintaining several links (Ferriani & MacMillan, 2017). Within innovative networks, increasing centrality aids innovation up to a point beyond which it tends to hurt innovation (Dong et al., 2017). In terms of change, actors with high centrality can be imprisoned in "maladaptive situations" or forced to exhibit undesirable behaviors (Borgatti & Foster, 2003, p. 994). Similarly, there are usually high risks and costs associated with making changes to components with high centrality because of the possible disruptions that the change may cause to several other components (Saraf et al., 2013; Harrison & Easton, 2002).

IT-enabled resources consist of a focal IT asset that is connected to other organizational resources including other IT assets. Connecting the focal IT asset to several resources (e.g., departments or functions) can lead to resource leveraging and performance (Nevo & Wade, 2011; Tanriverdi, 2006). However, connecting or integrating the focal IT asset with several resources can also lead to rigidity because of the cost and risk associated with making changes to the focal IT asset. Thus, the centrality of the components of an IT-enabled resource is a structural property that can influence the renewal of the IT-enabled resource to address shifting goals. We refer to the number of components that are connected to a focal component as the *component centrality* of the focal component.

2.4 Structural Properties and the Renewal of IT-enabled Resources

From the previous section, the structural properties of an IT-enabled resource consist of three properties namely, component flexibility, component coupling, and component centrality. We use the structural properties to extend Nevo and Wade's (2011, 2010) model on the formation of IT-enabled resources. This study concentrates on the systems end of the model that discusses the formation of synergy. We thus kindly refer the reader to Nevo and Wade (2011, 2010) for a detailed discussion on the resource-based view end of the model that discusses how synergy affords the IT-enabled resource strategic potentials, and how the strategic potentials lead to IT benefit. In this study, we assume that an IT-enabled resource loses its strategic potential to achieve an existing or a new goal when its synergy is disrupted (e.g., by misalignment), and that the strategic potential can be restored by realigning or reconfiguring the components of the IT-enabled resource to create a new synergy relevant for the existing or the new organizational goal. We thus focus on how the structural properties of an IT-enabled resource can enable or constrain its renewal.

Figure 1 below shows how we extend Nevo and Wade's (2011, 2010) conception of IT-enabled resources with the structural properties of an IT-enabled resource. Drawing on general systems theory, loose coupling theory, and social network theory, we suggest that the structural properties of an IT-enabled resource consist of component flexibility, component coupling, and component centrality and that the structural properties do influence the renewal of IT-enabled resources to sustain the derivation of IT benefits, especially in dynamic environments.

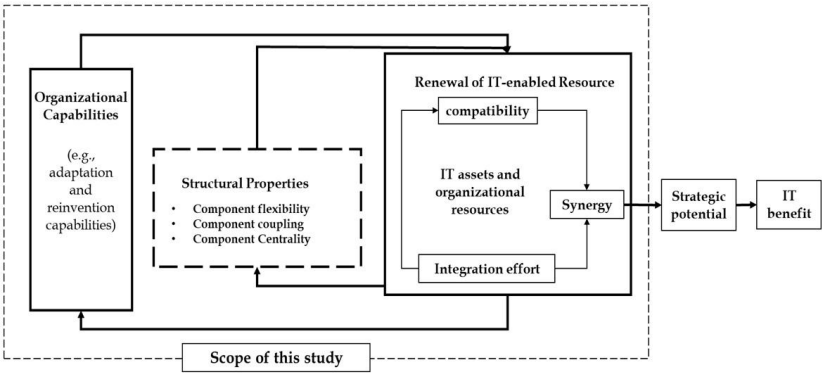

Figure 1 Renewal of IT-enabled Resources (Extension of Nevo and Wade (2010,2011))

3 Research Method

In this study, we seek to unravel and theorize the effects that the structural properties of IT-enabled resources have on their renewal. In that regard, we adopt the case study method in our theory-building process (Eisenhardt, 1989; Eisenhardt & Graebner, 2007). We adopt the case study method because it enables the study of complex phenomena that are embedded in their context (Lee, 1989; Yin, 1981, 2012). A case study provides the opportunity to uncover the nuances and complex dynamics that underlie how structural properties may enable or constrain the renewal of IT-enabled resources in an organizational context (Eisenhardt, 1989). Curry et al. (2009) assert that the case study method "can be useful when researchers are interested in looking beyond identified variables that are statistically linked with a desired effect to understand why a given intervention has a specific impact, how the impact occurs, and in what organizational context" (p. 1443).

We draw on published cases on post-implementation changes to IT assets and organizational resources (e.g., work processes) and on an in-depth case of how a university in Finland renewed its IT-enabled resource to address new teaching and learning goals during the Covid-19 pandemic. We refer to post-implementation changes as changes that are made to IT assets and work processes to achieve existing or new goals (e.g., Orlikowski, 1996; Jasperson et al., 2005; McGann & Lyytinen, 2008; Nevo et al., 2016; Robey et al., 2002). Post-implementation changes may include the extension or improvisation of current IT features and work processes and the development of new IT features and work processes.

We, therefore, approached this research in two stages. The first stage occurred from 2018 to 2019 and focused on conceptualizing and identifying the structural properties of IT-enabled resources. In 2018 and 2019, we selected and reviewed published case studies on post-implementation changes (see Lumor, 2019). We reviewed the narrative of each published case for the IT-enabled resource studied, the components and the structural properties of the IT-enabled resource, and the effects that the structural properties have on making changes to the IT-enabled resource. Our review of the published cases led us to identify the three theories (general systems theory, loose coupling theory, and social network theory) that inform our conceptualization of the structural properties of IT-enabled resources. See a brief discussion in Section 4 and a summary in Table A1 in Appendix A. The second stage occurred between 2020 and 2021 and focused on unraveling and theorizing the effects of the structural properties on the renewal of IT-enabled resources. To achieve that, we conducted an in-depth case study on how a university renewed and redeployed its IT-enabled resource in the pursuit of new organizational goals during the Covid-19 pandemic. Our focus was to study the IT-enabled resource, its structural properties, and how the structural properties enabled or constrained the renewal of the IT-enabled resource. The sudden nature of the change in response to national directives on the Covid-19 pandemic made the case interesting because it presented a dynamic environment where the effects of the structural properties can be apparent.

3.1 Case Description

The case university, as part of its digitalization strategy, has three objectives: the digitalization of education, the digitalization of research, and the creation of a smart campus. As part of the strategy to digitalize education, the case university combines IT assets and its teaching and learning processes to extend its teaching and learning capabilities (Nevo & Wade, 2011, 2010). We refer to the combination of IT assets and teaching and learning processes as *IT-enabled education*.

The case university is an international university with about 15000 students and 1600 teaching and research staff. The case university has used UniLMS (a pseudonym for a learning management system) since 2004. However, until 2016, UniLMS was not the primary learning management system for the university. The university replaced its primary learning management system because it lacked functionality and its data structure had become complex. User logins to UniLMS escalated from about a thousand per week before 2016 to over 100 thousand per week after UniLMS was made the primary learning management system.

UniLMS is an open-source learning management system whose first version was released in 2002 and the most recent version was released in 2021. UniLMS supports several pedagogical practices and can support IT-mediated learning modes including blended learning, distance education, and flipped classrooms. It is maintained by a head office and an open-source community of developers. It has a core with interfaces on which users, including universities and other institutions, can build using plugins to

deliver customized services and experiences. UniLMS is also interoperable with other IT assets at the case university.

At the time of this study, the entire case university uses only one instance of UniLMS which is connected to several IT assets and work processes across 11 faculties and institutes including an open university. IT-enabled education in the case university was made up of UniLMS connected to 11 faculties, UniSIM (a pseudonym for a student information system), OldUniSIM (a pseudonym for an old student information system) which is being phased out, and UniVideo (a pseudonym for an online file repository) on which educators upload recorded lectures and other teaching materials. Apart from the open university which will migrate from OldUniSIM to UniSIM in fall 2021, all other faculties and institutes have migrated to UniSIM. Unlike OldUniSIM which is an in-house system developed in the case university, UniSIM is a vendor system used by other universities and institutes across Finland.

Before the spring semester of 2020, the case university used UniLMS to support face-to-face teaching and learning. Generally, UniLMS was used to share course materials, organize discussion forums, and return student assignments. However, in response to a national guideline on the Covid-19 pandemic in March 2020, the case university redeployed *IT-enabled education* to achieve a new goal, namely, making all teaching and learning activities virtual. By theoretical sampling (Eisenhardt, 1989), this case provides a unique opportunity to study the intricacies of the structural property of an IT-enabled resource and how the structural properties enable or constrain the ability of the case university to transit from face-to-face to virtual education.

3.2 Data Collection

We conducted 22 semi-structured interviews between September 2020 to February 2021. Other sources of data include online reports and emails from the case university, especially concerning its response to the Covid-19 pandemic. Students and teachers who were randomly selected from faculty lists were contacted via email asking for an opportunity to discuss their experiences in transitioning from face-to-face to virtual learning. Also, an email was sent to the manager in charge of IT services in the case university asking for the opportunity to study the university's transition from face-to-face to virtual learning. The manager sent a list of potential interviewees that included technical administrators and other managers of IT services for the study. We also searched through the online community that supports UniLMS and recruited a few developers from the open-source community that maintains UniLMS. Table A1 in Appendix A presents a summary of the list of interviewees. Before the Covid-19 pandemic, the Open University already offered an open virtual learning environment. Therefore, the teaching and learning processes at the open university did not change much during the pandemic in pursuit of a new goal of moving from face-to-face to virtual learning. We, thus, did not include the students and teachers from the open university in this study.

3.3 Data Analysis

We transcribed the interview data verbatim and analyzed the data using Atlas.ti software. We employed an inductive and interpretive approach (Walsham, 1995, 2006) to code and analyze the data. First, we read and open-coded the data (i.e., open coding). According to Curry et al. (2009), codes are labels for cataloging key concepts without disrupting the context in which these concepts occur. We re-read the data to ensure that every relevant piece of data was coded. The coding was done with the definitions of the three structural properties in mind (Eisenhardt, 1989). After the data was open coded, the open codes were analyzed and grouped to form code groups or categories (i.e., axial coding). Finally, the categories were further grouped to form the relevant constructs for this study. The coding did not occur linearly, but through iterations from the codes to data, until the key constructs and their relationships emerged (Curry et al., 2009). Figure B1, Figure B2, and Figure B3 in Appendix B illustrate the transition from data through open codes, and axial codes to constructs.

4 Renewal of IT-enabled Resources in Published Empirical Cases

In this section, we briefly present manifestations of the structural properties in published empirical cases on post-implementation change. From the cases, we identify the IT-enabled resources, their components, and structural properties, and how the structural properties influence changes to or renewal of the IT-enabled resources (see Table A1 in Appendix A). We also discuss how organizational capabilities influence and are influenced by the renewal of IT-enabled resources.

4.1 Component Flexibility

The components of an IT-enabled resource co-evolve or at least adapt to fit each other during the formation of the IT-enabled resources (Goh et al., 2011). Thus, for each pair of components, at least one of the components should be flexible to allow the adaptation and reinvention necessary to appropriately integrate or combine the two components. In cases where the two components are flexible, they can co-evolve, each being adapted or reinvented to fit the other or to actualize affordances provided by the other (Leonardi, 2011). For example, Orlikowski (1996) describes a case study in which users in a customer support department adapted and reinvented a flexible incident tracking support system and their work processes to address existing and emerging organizational goals and to seize opportunities.

When a pair of components do not fit, yet one of them is inflexible, the flexible component is adapted, or workarounds are created to compensate for the rigidity of the inflexible component. Macredie and Sandom (1999) studied a case company that employed local improvisations and adaptations in its work processes to improve synergy between its work processes and an inflexible IT asset. In cases where the two components do not fit together and neither of them is flexible, the two may not be integrated but workarounds may be created to accomplish work tasks resulting in loosely connected components. For instance, Azad and King (2012) elaborate on how users created and maintained spreadsheets with which they supported their tax administration work processes because the tax administration system was inflexible and did not fit their work processes.

4.2 Component Coupling

According to loose coupling theory, component coupling describes the number and strength of connections or interdependencies among the components that form an IT-enabled resource (Orton & Weick, 1990; Perrow, 2011). Tightly connected components constrain change. Seethamraju (2009) found that tightly coupled IT assets and processes restrict the ability to reconfigure and deploy the IT assets and processes. They also found that when even flexible components are tightly coupled, their flexibility is derailed (Seethamraju, 2009).

Loosely connected components enable improvisation and change (Orton & Weick, 1990; Perrow, 2011). An example is the actions of project managers who obtained data from an ERP via a business warehouse and locally processed the data using a spreadsheet to meet their project budgeting needs (Berente et al., 2016). According to loose coupling theory, because loosely connected components have weak interdependencies and are not responsive to each other, the components may evolve indiscriminately (Orton & Weick, 1990; Perrow, 2011). Azad and King (2012) provide an example of loosely connected IT asset and work processes for tax administration which resulted in indiscriminate evolution of the IT asset and work processes. Similarly, Drummond (2008) presents an account of a focal IT asset loosely connected to other components and how they evolved erratically to stifle performance. Thus, loosely connected components may provide opportunities for change but derail the synergies and efficiency of an IT-enabled resource (Orton & Weick, 1990).

Components that have both tight and loose connections between them support efficiency (e.g., synergy) and effectiveness (e.g., change) (Orton & Weick, 1990). Berente et al. (2008) demonstrate how employees at NASA used tightly linked work processes and a focal IT asset to create efficiency and synergy but explored loosely coupled IT assets and work processes to enact change in information needs for project management.

4.3 Component Centrality

An IT-enabled resource can comprise a focal resource (e.g., an IT asset) connected to several other components, including IT assets. Our review of published cases shows that components with high component centrality can lead to the formation of synergy through resource leveraging and can enable and constrain change. According to social network theory, an IT asset with high centrality can promote resource leveraging. An ERP that connected different centers in NASA enabled resource visibility and project collaborations across the centers (Berente et al., 2008). When an IT-enabled resource has an IT asset that has high component centrality, the inflexibilities of any component can be compensated for by adapting or reinventing other components that are flexible. In other words, high centrality provides room to accommodate change. Davidson and Chismar (2007) studied an electronic health record that connected the work processes of physicians, nurses, and pharmacists. Nurses changed their work processes (e.g.,

entering work orders for doctors) to accommodate the inability of some doctors to change their work processes to fit the IT (Davidson & Chismar, 2007).

Nevertheless, evidence from the empirical application of social network theory shows that the high centrality of a component can increase the cost and risk associated with the renewal and redeployment of an IT-enabled resource. Rodon et al. (2011) provide a narrative of how individual organizations locally adapted and integrated an inter-organizational IS to increase productivity. However, the local adaptations and integration increased the risk and cost of updating the inter-organizational IS, which then reduced the productivity of the user organizations in the long run (Rodon et al., 2011). Similarly, Schneider et al. (2018) provide an account of how an organization obtained performance gains by integrating the interface of a cloud-based enterprise system with its work processes but faced severe disruptions in performance when the vendor updated the cloud-based enterprise system. Therefore, the component centrality of a component of an IT-enabled resource can support resource leveraging and performance and can also enable or constrain the renewal and redeployment of IT-enabled resources to address changing strategic imperatives.

4.4 Organizational Capabilities

During post-implementation, organizations (e.g., through users and support teams) exhibit different organizational capabilities in combining IT assets and other organizational resources (i.e., work processes) to form IT-enabled resources. Several empirical studies demonstrate the importance of organizational capabilities for combining IT assets and work processes. Users and support teams studied by Santhanam et al. (2007) exhibited organizational capabilities for tweaking existing IT features to accommodate work processes (e.g., resubmitting loan packages) and for developing new IT features (e.g., IT feature to hold templates for miscellaneous loan packages). The case company in Schneider et al. (2018) demonstrated organizational capabilities for customizing and adding new IT features (e.g., APIs) to the interface of a cloud-based enterprise system. Spierings et al. (2017) provide an example of users who demonstrated organizational capabilities for developing IT workarounds to abate additional transactional costs imposed by an IT asset and to gain efficiency. McGann and Lyytinen (2008) present a case study in which the case company demonstrated organizational capabilities for developing new IT features and work processes to address existing goals in shipping and to enable the organization to meet new and emerging requirements. Thus, organizational capabilities for combining IT assets and work processes can manifest as the capabilities with which IT assets and work processes are modified and combined to reinstate old ways of working, attain present goals, or meet new and emerging goals. We refer to the organizational capabilities for forming IT-enabled resources to reinstate old practices or attain present goals as adaptation capabilities, and organizational capabilities for forming IT-enabled resources to address new and emerging goals as reinvention capabilities (Nevo et al., 2016).

Organizational capabilities influence the extent of adaptation or reinvention that can be done to improve the compatibility and integration of IT assets and work processes to form IT-enabled resources. Where there are low organizational capabilities, IT assets, and work process adaptions and reinventions may be dysfunctional (Schneider et al., 2018). Thus, organizations augment their organizational capabilities (e.g., by training) (Spierings et al., 2017), or by hiring new staff (Macredie & Sandom, 1999). Alternatively, as support teams and users engage in adaptation and reinvention activities, they acquire contextual knowledge and build organizational capabilities. IT support teams and users engage in knowledge transfer whilst adapting IT assets and work processes (Santhanam et al., 2007). Those who engage in configuration activities may gain configuration capabilities associated with the IT assets and related work processes (Schneider et al., 2018). Spierings et al. (2017) observed that users intentionally engage in learning activities to develop quality and usable feral information systems (i.e., IT adaptations, and IT reinventions). In effect, on the one hand, organizational capabilities influence the renewal of IT-enabled resources and on the other hand, the renewal of IT-enabled resources builds new organizational capabilities and strengthens existing ones.

5 Renewal of an IT-enabled Resource in the Case University

In this section, we present our analysis of the data on the renewal of an IT-enabled resource (i.e., IT-enabled education) in the case university. To highlight the effects of the structural properties and organizational context on the renewal of *IT-enabled education* in the case university, we analyze *IT-enabled education* before and during the pandemic.

5.1 IT-enabled Education before the Covid-19 Pandemic

5.1.1 Organizational Context and Capability

Before Finland issued a guideline on the Covid-19 pandemic that resulted in the closure of the case university and the transition from face-to-face to virtual teaching and learning, UniLMS was used to support face-to-face teaching and learning processes. Although teaching activities were mostly done in the traditional classroom setting, educators used the features of UniLMS to different extents. Whereas some educators used UniLMS minimally, for example, to share course information and teaching slides, others used UniLMS extensively to offer supplementary lectures (e.g., through pre-recorded lectures), implement flipped classrooms, organize quizzes and assignments, and host online fora. An educator expressed how he used UniLMS this way, "mostly it [UniLMS] has been just a place where I have shared the slides, reading materials, and later the lecture video recordings linked from there" (Res17).

An educator's capabilities, including pedagogical skills and IT skills (e.g., for using UniLMS, UniSIM, and UniVideo) at the case university influence the extent to which the educator leverages IT assets to extend teaching and learning processes. Educators participate in formal skills development activities, seek help from colleagues, or engage in learning-by-doing to acquire the capability to extend teaching and learning processes with IT assets. One educator said, "I quite often have asked my colleagues in the past, like, where is the damn button for that? Where is that? Where can I find that? And... yeah, my colleagues have been quite helpful for that" (Res 13).

The service desk in the case university also provides IT related support in terms of IT configuration and integration and organizes skills training on how to use the different IT assets (especially, UniLMS, UniSIM, and UniVideo). Members of the service desk also collaborate with developers from the open-source community that maintains UniLMS to develop plugins to meet the needs of educators and learners in the case university. A manager puts it this way, "So there's a lot of pedagogical training and support, and then hands-on support and help desk for them. And then we also do a lot of technical development for them to support their needs" (Res 12).

Apart from capability, the internal and external environment of the case university also influenced the extent to which IT assets are used to extend teaching and learning processes. The case university allowed educators to be innovative about their pedagogical methods and the extent to which they integrated IT assets with teaching and learning processes. Educators, therefore, integrated IT assets with their teaching processes based on, for instance, the nature of the course (e.g., hands-on or theoretical) and the number of students enrolled in the course. Courses with a large number of learners tend to make use of UniLMS to extend the reach of teaching processes than courses with small numbers do.

> *So basically, [name of an educator] used to run the course, and it was completely in-person. And then I came in, and then I said, well, let's reach out to more students make this online…so there was the element of being there in person. And also, there was just an option that people could follow online as well.* (Res 13)

5.1.2 Component Centrality

IT-enabled education in the case university consists of multiple IT assets and work processes that are connected to each other and to other components outside the case university. UniLMS is connected to other IT assets (e.g., UniSIM and UniVideo), teaching and learning processes in 10 faculties and institutes, and an open university. UniSIM is connected to UniLMS, OldUniSIM, and several work processes in the case university. In addition, UniSIM is also used by other higher educational institutes in Finland. The IT assets (i.e., UniLMS, UniSIM, UniVideo) are linked together by several work processes including teaching, learning, and administrative processes. A manager explains the connections as follows.

> *Yeah, we have one instance [of UniLMS] that is used by the whole university, including Open University… we have integrations now between OldUniSIM and UniLMS, and UniSIM and UniLMS. … a teacher can order a course area to UniLMS and then it will be created automatically. And the teacher can send the students from UniSIM to UniLMS*. (Res 12)

5.1.3 Component Flexibility

The IT assets and work processes in the case university have different levels of component flexibility. UniSIM, unlike OldUniSIM, is not an in-house student information system. Educators and students find its features inflexible and therefore face several constraints using UniSIM. They expressed concerns about how rigid and unforgiving the features of UniSIM are. For example, an educator explains how UniSIM's inflexibility impedes the ability of educators to change or update a learner's grade. The educator said, "Well, if you import a grade, like, if you put it like by mistake, wrong, and you can't fix it anymore…" (Res 9).

UniLMS, on the other hand, was generally seen as flexible perhaps because UniLMS is developed to support different pedagogical methods and can be customized via plugins. Educators experiment with existing features in UniLMS and demand for and use new features that the help desk implements via plugins. A manager puts it this way, "Well, UniLMS supports many kinds of pedagogical views and processes. So it's quite good system in that way because in an ideal world, the pedagogical processes don't have to adapt to technology" (Res 12).

Apart from the IT assets, work processes in the case university vary in flexibility. For instance, teaching processes are generally flexible allowing educators to choose the methods of teaching and the assessments. Conversely, the case university has a help-seeking process that interviewees see as rigid. The help-seeking process disallows direct contact with personnel at the help desk. Rather, to seek help, educators and learners need to navigate through levels of options on an online portal to identify the right online form to use in seeking help. Educators complained that the help-seeking process is rigid, complex, and slow and in as much as they could they sought assistance from elsewhere, especially from peers. An educator explains it this way,

> *I have to say, I really am not a fan of the new help system. It's horrible. It's completely kind of dehumanized, you know. I mean the help structure in like, knowing that you have to go on this, web page or space and then find the right link, to lead to the right field to ask the right question for the right people and then wait for the response.* (Res 14)

5.1.4 Component Coupling

Component coupling indicates the number and strength of the links between the components of an IT-enabled resource. All three types of component coupling exist among the IT assets and work processes at the case university. Several teaching and learning processes in the case university are loosely coupled to UniLMS via plugins. This allows the help desk to quickly make changes to or update UniLMS without disrupting the teaching and learning processes in the case university.

Some links between UniLMS and UniSIM are tightly coupled. For instance, UniSIM allows educators to transfer learners who have registered for a course in UniSIM to only one course group in UniLMS. An educator explains that at times, it is important to split learners into groups and transfer them to different course groups in UniLMS, but UniSIM does not allow that.

> *if there's one group for the course, then UniSIM can automatically put all the students in UniLMS, right, which is nice. But I have many groups, and if I try to…do it, it'll put all the students from the course into one group in UniLMS, which is not what I want.* (Res 8)

Another example of a tight link is the link along which grades are exported from UniLMS to UniSIM. Since making changes to UniSIM is difficult, educators and learners explore other means, including leveraging work processes and other IT assets, to go around the tight links between UniLMS and UniSIM. For example, educators leverage other IT assets (e.g., spreadsheet) to help manually enter students' grades from UniLMS to UniSIM. Educators also explore the work processes of those who have administrative rights to update student grades because UniSIM does not allow an educator to update a grade once it is entered.

> *And also, when someone takes the re-exam, and they already have one grade, and then they need to kind of get the new grade up in the system, you can't put it there because you already put one grade. So, you need to email someone to make it happen for you. …it's just like not very helpful when you have to like make up all these new routines to work around UniSIM problems.* (Res 9)

Before the Covid-19 pandemic, teaching and learning processes were mostly linked by activities in the physical classroom and activities online (e.g., via UniLMS and UniSIM). The physical classroom gave educators better control over teaching and learning processes. For instance, educators could set class attendance requirements to enforce class attendance. They could communicate course information to students in person or verify in person whether learners have received course information that was sent via email or UniLMS. They could also use interactions, including non-verbal communications, with students to tailor the delivery of course materials and to offer guidance on assignments that students submit via UniLMS. Activities in the physical classroom are augmented with activities on UniLMS (e.g., to provide learners access to course materials), and an online space to discuss and submit assignments.

The physical classroom also provided the opportunity for learners to have in-person interactions with colleagues and educators. Learners believe the physical presence and interactions make learning easier and more effective because the interactions allow them to discuss course contents with colleagues or ask for clarifications from educators. Learners also believe that clear schedules and presence in class enable them to focus and derive good learning experiences from courses. These links between teaching and learning processes, and the *reachness* (Sambamurthy et al., 2003) of course materials in UniLMS made the teaching and learning processes efficient and effective.

5.2 IT-enabled Education During the Covid-19 Pandemic

5.2.1 Organizational Context and Capability

On a Friday in March 2020, the leadership of the case university sent an email to notify all educators and learners that from the following Monday, all teaching and learning processes will be virtual. However, first-year learners could still have face-to-face classes and other group activities within set limits. However, when the Covid-19 pandemic became severe, the case university canceled all in-person activities even for first-year learners. All teaching and learning activities became virtual. A manager put it this way.

> *we're talking about the pandemic, because of course, that has been a huge shift in the sense that we had to make a very fast shift and change from face to face and blended learning to hybrid learning or even 100% distance online learning.* (Res 12)

Although the leadership of the case university mandated all teaching and learning processes should be virtual, the leadership did not provide formal guidelines on how making education virtual should happen. There was apparently no formal guidance on how educators were to structure and deliver their lessons, conduct examinations and assessments, and communicate with learners. Likewise, although the leadership of the university recommended that teaching and learning activities should be managed using UniLMS, educators could choose whichever learning management systems they deem fit for their purpose. One educator expressed it this way,

> *Well, just some general directives, nothing specific. So basically, teachers could make their decisions on their own.* (Res 16)

Nevertheless, the service desk does not provide support for the other learning management systems, nor integrate them with UniLMS. A manager clarified,

> *[Help Desk], we only provide UniLMS. And we don't say the teachers have to use UniLMS, but they can use [list of other learning management systems], but we don't maintain those.* (Res 12)

The generic nature of guidelines from the leadership of the case university allowed educators to freely pick and choose teaching methods and IT assets with which they quickly moved their courses online.

> *it practically happened in during one week and I remember Friday, the message was received. We won't be coming to university next Monday. You have practically weekend time to prepare or move your course to online. So, it wasn't formal and that's mainly because there was no time for that.* (Res 17)

Whereas the majority of educators used UniLMS to organize and teach their courses, few educators used learning management systems that were not supported by the help desk nor integrated with UniLMS. However, across the case university, conducting and recording lectures using IT assets, for instance, Zoom and Teams, quickly became a common practice. Educators who used recorded lectures before the closure of the case university experienced the least disruption because they already had the capability to reorganize IT assets and teaching and learning processes to achieve the new organizational goal. Those

who relied heavily on face-to-face lectures needed to quickly build the capability to reorganize IT assets and teaching and learning processes to take their courses virtual. A manager illustrates this by saying,

> *Some of the teachers have to learn very many new skills and tools rapidly because of this change, so there has been a lot of learning and trial and error and training and support happening on that level.* (Res 12)

The Help Desk created and made available learning instructions on how educators can use IT assets to make their teaching processes virtual.

Some faculty members organize online activities where educators provide peer-led tutorials for their colleagues on pedagogical practices and how to use IT assets to make learning virtual. For example, one educator said,

> *we actually just had a meeting before this interview with my faculty, and then I was able to kind of give guidance for them how to use UniLMS because I had listened to those videos that are in our intranet*. (Res 11)

5.2.2 Component Centrality

The IT assets including UniLMS, UniSIM, and UniVideo became more central when teaching and learning processes became virtual. UniLMS, which was used to support classroom activities, became the main space for teaching and learning activities. More educators across the case university also uploaded lecture videos on UniVideo to support the transition to virtual teaching and learning processes. Following the requests of educators across the case university, the help desk added new features to UniLMS to support teaching and learning activities across the case university. Because all faculties and institutes in the case university use the same instance of UniLMS, configurations and new features added to UniLMS can be used by all educators and learners across the case university. This makes the effort of the help desk effective and efficient.

However, UniSIM did not change because of its high component centrality. Apart from serving all faculties in the case university, UniSIM is used by several other universities and institutions in Finland. The UniSIM is therefore difficult to adapt or reinvent to support the workflows and emerging goals of the case university. A manager explained,

> *UniSIM is now a good example of an IT system that we really cannot modify… it's shared by other higher education institutions as well. … then we find a workaround or do integrations or change the processes or, do extra manual work somewhere. That's, how they [changes] usually are handled.* (Rep 12)

Educators and learners continued to work around the low component flexibility of UniSIM by leveraging other IT and work processes that are connected to UniSIM and UniLMS to perform their work tasks. In effect, the component centrality of UniLMS and UniSIM makes up for the low component flexibility of UniSIM by providing alternative paths along which work tasks can be completed.

5.2.3 Component Flexibility

The component flexibility of work processes and IT assets also became more apparent when educators were moving teaching and learning processes online. Educators were able to adapt and reinvent features of UniLMS to make teaching and learning processes virtual. Different educators, depending on their pedagogical needs, made different use of UniLMS. This was possible because UniLMS can be adapted or reinvented to support different pedagogical methods and principles.

Educators also adapted existing teaching and learning processes (e.g., assessment, lecture, and learner-engagement processes), to make teaching and learning processes virtual *and* effective. For instance, educators host and record live lectures using IT assets like Zoom, develop screencasts and upload the videos on UniVideo, and make the links available to learners via UniLMS. An educator expresses it this way,

> *When the pandemic first started, I wasn't really sure how we could do the recordings and where we could store them. … And then they told us that, okay, now you can record your Zoom lectures and put them on UniVideo. So, I started doing that.* (Res 8)

Processes that are inflexible impeded the efforts to make learning and teaching virtual. Inflexible processes remained unchanged but were mostly avoided and rather, existing flexible processes were leveraged, or new processes were enacted to get work tasks accomplished. For instance, instead of using the new help-seeking process, educators find other means of getting help during the transition from the physical classroom to virtual teaching and learning.

5.2.4 Component Coupling

The types of coupling that existed among IT assets and work processes influenced the ability of the case university to renew and redeploy the IT assets and work processes to meet the new goal of making teaching and learning processes virtual. UniLMS is loosely coupled to teaching and learning processes across the case university via plugins and APIs. This enables the help desk to effect changes that meet the needs of individual faculties and institutes without affecting the performance of other faculties and institutes in the case university. It is apparent that the loose links at the interfaces of UniLMS abate the cost and risk of the centrality of UniLMS associated with change. Conversely, UniSIM is not so. The help desk could not perform changes to UniSIM to meet the demands of the case university because changes to UniSIM will have performance implications for other institutions across Finland that use UniSIM.

Loose links between teaching and learning processes also allowed educators to adapt or reinvent and redeploy teaching and learning processes to offer virtual education. When activities in the physical classroom were discontinued, most tight links that connected teaching and learning processes were broken and the processes became coupled. That is, they were connected mostly by loose links such that they were almost non-responsive to each other.

The loose links between teaching and learning processes allowed educators to freely reassemble IT assets and teaching and learning processes to achieve the new goal of offering virtual education. Nevertheless, although the loose links aided the renewal of the teaching and learning processes, the processes were not effective because they were not responsive to each other. Educators were not sure of the extent to which learners were engaged or participating in the learning process. Educators indicated that whereas they can observe a learner's activity in UniLMS or see a learner login to a live lecture (e.g., on Zoom and Teams) such observations do not necessarily imply the learner's active participation. Some other educators observed that students may tick boxes to show that they have listened to a recorded lecture or read course materials in UniLMS whilst they might not have done so.

> *if you click the link, the box will be checked. So, for example, for the reading materials or articles, once you click that, open the article, that box will be checked. I started using that and thought it would help students to keep the pace up. But in practice, that's just if you click the link, it doesn't mean that you looked at the lecture or read the article.* (Res 17)

Learners indicated that virtual teaching and learning processes that are void of tight links (e.g., clear schedules and weekly deadlines) affect their concentration and ability to derive good learning experiences from the virtual processes. They also highlighted the need for interactions with peers and educators in the virtual learning environment. A learner expressed it this way,

> *I can't focus that easily through the online classes. So, I find it very easy to be distracted because you have internet, you have many windows where you can open during the class*. (Res 19)

As a remedy, educators explored features in UniLMS and other IT assets and processes to enact tight links between teaching and learning processes. For instance, educators set tight schedules that force learners to submit weekly assignments, make learners read course materials and participate in small group discussions during live lectures, randomly assign short tasks to learners during live lectures as a way of ensuring learners are present and attentive, and make learners give feedback on their colleagues' assignments.

> *Therefore, I've been thinking that it is required to have several deadlines throughout the course, maybe some kind of weekly assignments. [Okay…], or something like that. So, the students could keep the pace of learning.* (Res 17)

The tight links between teaching and learning processes helped restore the responsiveness of the processes to each other and make them effective and efficient. For example, a learner said, "so far, I feel that I'm learning more through the assignments because I concentrate better, and I know that I have this time to complete the assignments. So, I just spent and focus my time there" (Res 19).

Therefore, though loose links can abate the cost of high component centrality and provide the opportunity to enact changes, tight links are needed, especially after a change, to reinstate the responsiveness of the components to each other, thus enabling efficiency and synergy.

6 Findings and Propositions

In this section, we present the findings from our analysis of published empirical cases and primary case studies and make propositions regarding the effects of the structural properties and organizational capabilities on the renewal of IT-enabled resources.

This study focuses on the effects of the structural properties of an IT-enabled resource on the renewal of the IT-enabled resource to address new strategic imperatives, thus sustaining the derivation of IT benefits. The study draws on and extends the conception of IT-enabled resources by Nevo and Wade (2011, 2010). However, this study focuses on the renewal of IT-enabled resources and assumes that the relationship between synergy and organizational benefit is a given fact because that relationship has been empirically studied (e.g., Nevo & Wade, 2011). Our study rather focuses on the structural properties that emerge when IT-enabled resources are formed and renewed and how the structural properties enable or constrain the renewal of IT-enabled resources.

We draw on relevant theories, a review of published cases, and the analysis of in-depth case data to propose a model (see Figure 2) and make propositions regarding the effects of the structural properties and organizational capabilities on the renewal of IT-enabled resources to sustain the derivation of IT benefits. We discuss these effects and the propositions in the sub-sections that follow.

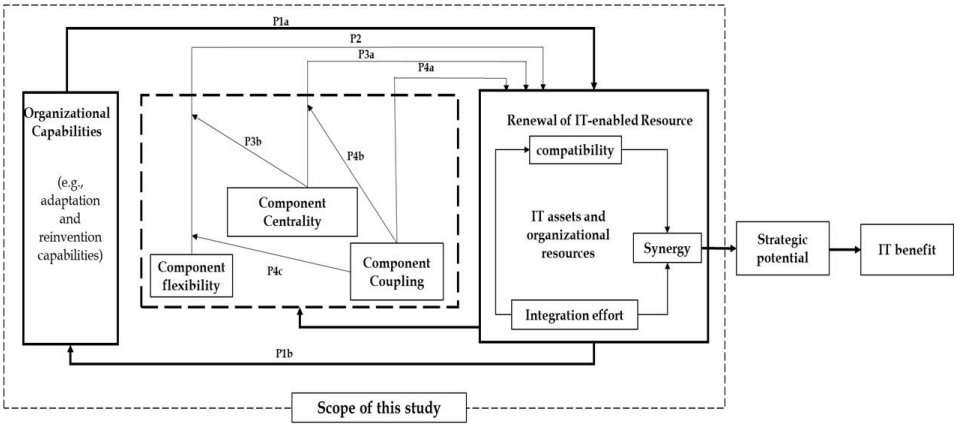

Figure 2. Structural Properties and Renewal of IT-Enabled Resources

6.1 Organizational Capability and Renewal of an IT-enabled Resource

As we discussed earlier, organizational capabilities are important in the formation and renewal of IT-enabled resources (e.g., Santhanam et al., 2007; Schneider et al., 2018). Further, the cases show that as organizations (i.e., users and support teams) engage in the formation and renewal of IT-enabled resources, they extend existing or build new capabilities (e.g., Spierings et al., 2017). From the analysis of our case data, we note that educators who had the capability to adapt IT assets (e.g., UniLMS) and work processes (e.g., teaching processes) were quicker at renewing IT-enabled education (i.e., transiting from face-to-face to virtual teaching and learning) in the case university. We also observed that whilst educators try to renew and redeploy their IT-enabled education to meet the new goal of the case university, they enhanced their existing skills and capabilities, or acquired new ones. Based on the analysis of published cases and on observations from our data we make the following propositions.

Proposition 1a (P1a): Organizations with the capability to adapt and reinvent their IT and work processes are effective at renewing their IT-enabled resources to address new and emerging goals.

Proposition 1b (P1b): Whilst organizations engage in the renewal of their IT-enabled resources to address new goals, they strengthen existing capabilities or develop new ones.

6.2 Component Flexibility and Renewal of an IT-enabled Resource

The component flexibility of an IT-enabled resource is an important factor that influences the extent to which an IT-enabled resource can be renewed to pursue existing or new goals. The published empirical cases illustrate the importance of the flexibility of IT assets (e.g., Orlikowski, 1996) and the flexibility of work processes (e.g., Macredie & Sandom, 1999) in an organization's effort to deploy its resources in pursuance of existing and new goals. For instance, a flexible incident tracking support system (an IT asset) and work processes enabled users to adapt and reinvent the IT asset and work processes to their work context and to seize opportunities (Orlikowski, 1996).

In the case university, the high component flexibility of UniLMS and teaching processes enabled educators to renew and redeploy their IT-enabled education resources to offer virtual education. Educators also recounted how the low component flexibility of certain processes (e.g., help-seeking process), and IT assets (e.g., UniSIM), impeded their efforts and forced them to leverage other IT assets and processes to work around the low component flexibility. We, therefore, make the following proposition:

> **Proposition 2 (P2): Generally, the component flexibility of components in an IT-enabled resource influences the renewal of the IT-enabled resource to meet existing or new goals.**

6.3 Component Centrality and Renewal of an IT-enabled Resource

When a component (e.g., a focal IT asset) in an IT-enable resource is connected to several other components, the cost and risk associated with making changes to the component is high because of its high component centrality (Saraf et al., 2013; Harrison & Easton, 2002), especially if the changes will affect the interfaces to which the other components are connected (Rodon et al., 2011). The high component centrality of an IOIS and individual adaptations that each user organization made to integrate the IOIS reduced the adaptability of the IOIS, increased the risk and cost of updating the IOIS, and reduced the productivity of user organizations (Rodon et al., 2011). Updating a cloud-based enterprise system can be costly to the performance of a user organization that has adapted and integrated the cloud-based enterprise system with several of its work processes (Schneider et al., 2018). In the case university, a manager's narrative indicates that the case university is not able to readily make changes to UniSIM because it is used by other universities and institutions (i.e., its centrality). Also, large-scale changes to UniLMS are scheduled for off-peak moments because of the potential disruptions that the high component centrality of UniLMS can have on teaching and learning processes.

Nevertheless, component centrality (e.g., of the focal IT asset), can provide access to alternative paths along which changes can be effected (Davidson & Chismar, 2007). Our analysis of the data shows that educators worked around inflexible processes by using other IT assets and work processes. Learners worked around inflexible IT features and work processes by leveraging the work processes of educators. Thus, we make the following propositions.

> **Proposition 3a (P3a): The component centrality of a component (e.g., a focal IT asset) in an IT-enabled resource increases the risk, cost, and disruptiveness of renewing the IT-enabled resource to meet new goals.**

> **Proposition 3b (P3b): The effect that the component flexibility of a component (e.g., a focal IT asset) has on the renewal of an IT-enabled resource is moderated by its component centrality.**

6.4 Component Coupling and Renewal of an IT-enabled Resource.

The number and strength of the links among the components of an IT-enabled resource (i.e., component coupling) affect the renewal and redeployment of the IT-enabled resource to achieve new goals. Tightly coupled components may constrain the renewal and redeployment of an IT-enabled resource, whilst loosely coupled components can enable the renewal and redeployment of the IT-enabled resource. Generally, coupled (i.e., loosely linked) components are readily redeployable but are also mostly dysfunctional. For example, a firm was unable to renew and redeploy its work processes because its IT assets, structures, and processes were tightly coupled (Seethamraju, 2009). Physicians, nurses, and pharmacists were able to handle emergencies because they loosely coupled their work processes and a medication dispensing system (Azad & King, 2008). Coupled tax information systems and tax

administration processes evolved separately weakening the tax administration capabilities at a case organization (Azad & King, 2012).

In the case university, there were tight links for instance, between UniSIM and UniLMS through the grade reporting function in UniSIM; and between educators and the help desk through online help forms. These tight links constrain the ability to make changes. Educators had to create workarounds and leverage other processes connected to UniLMS. Loosely coupled teaching and learning processes allow educators to, on the one hand, accommodate changes and allow learners space and time to learn. On the other hand, they allow educators to enact tight weekly schedules (e.g., for returning assignments), that keep learners engaged and on track. Coupled IT and work processes are loosely linked and can be easily rearranged during the renewal of an IT-enabled resource. For instance, during the early stages of the transition, teaching processes were loosely linked with learning processes such that educators and learners were able to enact changes.

The component coupling also has implications for the effects that component centrality has on the renewal of IT-enabled resources to address shifting strategic imperatives. For example, UniLMS has high component centrality in that it is used by all the faculties and institutes in the case university. However, because the several faculties and institutes and their work processes are loosely coupled to the core of UniLMS via plugins, the cost and risk of making changes to UniLMS are low. On the contrary, when several components are tightly coupled to a focal component (e.g., a focal IT asset) in an IT-enabled resource, changes to the focal component can be very costly, risky, and disruptive even if the focal component is flexible. UniSIM is tightly coupled with other IT assets and processes within the case university, and with other universities and institutions within Finland, making it very difficult for the case university to make changes to UniSIM. Also, the example of the IOIS in Rodon et al. (2011) and that of the cloud-based enterprise system in Schneider et al. (2018) illustrate how costly, risky, and disruptive it is to make changes to a focal component that is tightly coupled to several other components even when the focal component is flexible. Based on these findings, we make the following propositions.

Proposition 4a (P4a): The type of coupling that exists among the components of an IT-enabled resource affects the renewal of the IT-enabled resource to address new goals.

Proposition 4b (P4b): The effect that the component centrality of a focal component (e.g., a focal IT asset) has on the renewal of an IT-enabled resource is moderated by its component coupling (i.e., the type of coupling between the focal component and other components).

Proposition 4c (P4c): The effect that the component flexibility of a focal component (especially a focal IT asset) has on the renewal of an IT-enabled resource is moderated by its component coupling (i.e., the type of coupling between the focal component and other components).

7 Discussion

This study aims to understand how the structural properties of an IT-enabled resource can influence the renewal of the IT-enabled resource to achieve merging goals, thus sustaining the derivation of IT benefits. This inquiry is essential because of the importance and temporality of IT benefits, especially in dynamic environments (Kohli & Grover, 2008; Wade & Hulland, 2004), and the paradoxical effects of integration needed to endow IT-enabled resources with synergy and strategic potential (Saraf et al., 2013; Tanriverdi & Du, 2020).

The study, therefore, draws on relevant theories, an analysis of published empirical cases on post-implementation change, and an in-depth case study of an IT-enabled education in a university in Finland to understand the structural properties of IT-enabled resources and to theorize how the structural properties can enable or constrain the renewal of IT-enabled resources to achieve new goals. The results show that the structural properties of an IT-enabled resource consist of three properties namely component flexibility, component coupling, and component centrality. The three properties individually and collectively influence the renewal of IT-enabled resources. We discuss the research and managerial implications of the study in the sub-sections that follow.

7.1 Implications for Research

The study extends Nevo and Wade's (2011, 2010) conception of IT-enabled resources by going beyond the formation of IT-enabled resources to study the structural properties that ensue when IT and other organizational resources are combined and integrated to form an IT-enabled resource. That is, whereas Nevo and Wade (2011, 2010) are concerned with the initial formation of IT-enabled resources as a means by which IT assets result in IT benefits, this study is concerned with the structural properties (i.e., component flexibility, component coupling, component centrality) that emerge during the formation of IT-enabled resources and how the structural properties can influence the renewal of IT-enabled resources to sustain the derivation of IT benefits.

Further, the study notes that an IT-enabled resource is rarely formed from a combination of one IT asset and one organizational resource (e.g., a work process). Rather, it is formed by connecting a focal organizational resource (which may be an IT asset) to several other organizational resources. For example, the literature on shared services (e.g., Fielt et al., 2014), collaboration (e.g., Smith & McKeen, 2011; Chen et al., 2021; Flak et al., 2022), and digital platforms (e.g., Sandberg et al., 2020) demonstrate the interconnectedness and centrality of organizational resources (especially IT assets) mostly for resource leveraging. Therefore, whereas earlier research (e.g., Someh et al., 2019; Nevo & Wade, 2011) isolated an IT asset and a work process for clarity during the initial study of IT-enabled resources, this study considers a nuanced detail of the complex structure of IT-enabled resources to improve our understanding and guide future research on the structural properties of IT-enabled resources.

The effect of component flexibility on the renewal of IT-enabled resources highlights the need for IT assets and other organizational resources to be flexible. IS research concentrates largely on the flexibility of IT assets and infrastructure (Benitez et al., 2018; Mikalef et al., 2021; Tallon & Pinsonneault, 2011). However, a flexible IT infrastructure tightly integrated with rigid work processes can undermine the flexibility of the IT infrastructure, in that changes to the IT infrastructure will be disruptive or constrained (Rodon et al., 2011; Schneider et al., 2018; Tanriverdi & Du, 2020). Since an IT-enabled resource, rather than an IT asset, is the unit for deriving IT benefits, IS research and practice should also be concerned about the flexibility of other organizational resources and the whole IT-enabled resource in the discourse on renewing IT-enabled resources and sustaining the derivation of IT benefits.

The effects of component coupling reveal a trade-off between the synergy or value potential of an IT-enabled resource and its renewal. Tight integration of the components of an IT-enabled resource may result in synergy (Nevo & Wade, 2011, 2010) but can constrain the renewal of the IT-enabled resource. This finding affirms the importance of integration in the formation of synergy but also calls for research to closely consider the long-term effects of integration activities. Apart from delineating horizontal and vertical integration (Seethamraju, 2009), a careful orchestration of tight and loose links (i.e., loose coupling) among the components of an IT-enabled resource is therefore needed for synergy and the ability to change. Research should therefore delineate integration activities that lead to the formation of synergy and those that enable renewal of IT-enabled resources.

Component centrality affects the renewal and redeployment of IT-enabled resources in two important ways. On the one hand, changes to a focal component (e.g., a focal IT asset) with high component centrality, can be costly and risky, because of the potential disruption the changes may cause to other components. However, the disruptiveness of the change depends on how tightly or loosely the other components are connected to the focal component. On the other hand, the high component centrality of a focal component provides alternative paths for effecting changes that would have otherwise been constrained by the low component flexibility of other components. This intricate understanding of the effect of component centrality on the renewal of IT-enabled resources lends support to the disputed relationship between IT and organizational agility (Liang et al., 2017; Van Oosterhout et al., 2006), and begs a nuanced approach to research on concepts, such as IT connectedness, inter-organizational infrastructure, and digital platforms, that promote component centrality.

Taken together, the three structural properties provide a comprehensive view of the internal structures that emerge during the formation of resource combinations and how the structures influence the renewal of resource combinations to address new and emerging needs. The complementarity among the three structural properties reflects how the underlining theories (i.e., general systems theory, loosely coupling theory, and social network theory) complement each other in conceptualizing the structural properties of an IT-enabled resource. Research that considers only general systems theory (e.g., Nevo & Wade, 2010) may highlight the importance of high integration in the formation of synergy but miss, from loose coupling

theory and social network theory perspectives, the effect of such integration on the ability to renew the resource to sustain the derivation of benefits.

In that regard, this study sheds light on the dynamic nature of resources. Resources are dynamic and their structures evolve over time (Le Breton-Miller & Miller, 2015; Nevo & Wade, 2010; Sirmon et al., 2008; Wade & Hulland, 2004). The dynamic nature of a resource lies in the extent to which the resource can change in response to stimuli (Le Breton-Miller & Miller, 2015) or be reconfigured and combined with other resources to extend existing capabilities or produce new ones (Nevo & Wade, 2010; Sirmon et al., 2008). Research on the dynamic nature of resources mainly highlights how new capabilities are formed by combining resources, or by renewing/reconfiguring resources (Drnevich & Kriauciunas, 2011; Li & Chan, 2019; Queiroz et al., 2018; Winter, 2003). This view highlights the effect that external factors (e.g., dynamic capabilities and resource reconfiguration capabilities) have on the dynamic nature of a resource and assumes that resources are inherently renewable. Our research takes an alternative but complementary view. This study furthers our understanding of the dynamic nature of resources by explaining the internal factors (i.e., structural properties) of a resource that determines the extent to which the resource can yield itself to renewal. In other words, it explicates the structural properties that emerge during the formation of resources and how they enable or constrain the dynamic nature of resources (i.e., the ability of resources to change or be renewed to attain new goals). This view complements the dynamic capabilities view and partly explains why a firm with a dynamic capability, for example, our case university, can renew certain resources but cannot renew others.

Further, the study adds to the discourse on how IT assets can influence organizational performance, including sustained competitive advantage. The literature has shown that IT assets can, through the formation of synergy, contribute to competitive advantage but questions whether IT assets can contribute to sustained competitive advantage since IT benefits are usually short-lived (Mata et al., 1995; Melville et al., 2004; Nevo & Wade, 2011; Schryen, 2013; Wade & Hulland, 2004). Based on our findings, we argue that IT assets can contribute to a sustained competitive advantage when IT assets are combined with other organizational resources to form IT-enabled resources in ways that endow the IT-enabled resources with the structural properties that enable their renewal to create successive or a series of temporary competitive advantages (Sirmon et al., 2010, 2011). Thus this study responds to how IT assets, other organizational resources, and capabilities can jointly create completive value (Schryen, 2013), and sustain the creation of the value, especially in dynamic environments (Kohli & Grover, 2008; Schryen, 2013; Wade & Hulland, 2004).

Furthermore, the findings support existing theories on organizational capabilities. Existing theories (e.g., Helfat & Peteraf, 2003) suggest that organizations form, develop, and modify their capabilities over time through acquisitions and organizational learning. In line with existing literature on organizational capabilities, this study finds that on the one hand, organizations (through individuals and teams) employ their existing capabilities to form and renew resources, and on the other hand, organizations develop new capabilities or strengthen existing ones as they form and renew resources (see Li & Chan, 2019). Thus, the trajectory along which organizations develop their capabilities will depend partly on the structural properties of resources that they form and renew.

7.2 Managerial Implications

We discuss how managers can sustain the derivation of IT benefits by leveraging the structural properties that emerge during the formation of IT-enabled resources in ways that can enable the renewal of IT-enabled resources to create “shifting synergies” needed to address shifting organizational goals, especially in dynamic environments (Eisenhardt & Martin, 2000, p. 1107). First, managers, especially those in charge of IT-enabled resources, should shift attention from architecting and managing the characteristics of IT assets (e.g., IT flexibility) to architecting and managing the structural properties of IT-enabled resources. Since changes to even a flexible IT asset can be constrained if the IT asset is tightly coupled with several other organizational resources (Seethamraju, 2009), managers need to comprehensively consider the structural properties of each component whilst architecting and managing IT-enabled resources.

Second, during the formation and renewal of IT-enabled resources, managers should not only focus on integrating (e.g., tightly coupling) their resources to form IT-enabled resources (or synergy) to address current needs at the expense of the ability to renew the IT-enabled resource in pursuit of future needs. Instead, they should consider the interplay among the three structural properties and their effect on synergy and change. For instance, governments embarking on developing shared IT services (Chen et

al., 2021) can establish a centralized platform to pursue resource leveraging and synergy but loosely couple their flexible processes and resources to the shared platform to allow for change and autonomy. Like in our case university, managers pursuing digital transformation and agility through bimodal IT (Haffke et al., 2017) can use high centrality and tight links to establish a stable core whilst deploying boundary resources (e.g., APIs) (Zapadka et al., 2022) to enable agility through experimentation.

Third, managers should not only foster the development of capabilities that enable them to combine IT assets and other organizational resources to form IT-enabled resources with which they meet current goals. They should also invest in the development of capabilities that make the IT-enabled resources renewable to meet shifting strategic imperatives. In other words, managers should invest in capabilities that enable the formation of an IT-enabled resource and the capabilities that endow the IT-enabled resource with the structural properties that enable the renewal and redeployment of the IT-enabled resources to sustain the derivation of IT benefits. Further, managers should pay particular attention to the activities that result in the formation of enabling structural properties and orchestrate means by which experiences from such activities are captured and shared to extend organizational capabilities on the formation and renewal of IT-enabled resources.

8 Limitations

This study has a couple of limitations. First, the findings from the literature on the structural properties of IT-enabled resources are limited by the scant literature on post-implementation changes. However, by drawing on a review of 18 distinct published empirical cases, and the complementarity among the three theories (general systems theory, loose coupling theory, and social network theory), this study provides rich insights into the structural properties of IT-enabled resources and the factors that influence their formation.

Second, the study employs a single primary case study in a theory-building endeavor to theorize the relationship between the structural properties and the renewal of IT-enabled resources. According to Eisenhardt (1989), theories from case studies are stronger when they are based on multiple case studies. Thus, this study leveraged the narratives from the 18 published cases to compensate for the limitation of using one primary case in the theory-building process. The eight propositions from this study, therefore, emerged from an interplay between the 18 published cases and the one primary case. Future research can employ other cases to refine the propositions. Further, we also invite researchers to test our propositions in different contexts using a variety of research methods and to extend our model.

9 Areas for Future Research

This study identifies three avenues for future research on the structural properties of IT-enabled resources and their role in sustaining the derivation of IT benefits. Firstly, future research can examine our model and its associated propositions, especially using configurational approaches (Levallet et al., 2020; Pappas & Woodside, 2021) to explore the configurations of the three interrelated structural properties that enable renewal and those that constrain renewal. Such research will contribute to improving our understanding of the complexities of IT-enabled resources and how their structural properties evolve (Levallet et al., 2020) to enable or constrain the derivation of IT benefits in the long term.

Secondly, future research can also investigate organizational capabilities and practices that lead to the formation of synergy and enable the renewal of IT-enabled resources and contrast them with capabilities and practices that may lead to the formation of synergy but constrain the renewal of IT-enabled resources. We invite scholars, especially those who study architectures (e.g., enterprise architecture), to engage in research along these lines.

Third, since an IT-enabled resource, rather than only an IT asset, is the vehicle for deriving IT benefit, future research should consider a broader set of capabilities beyond those that focus on only the IT asset, for example, IT capability (Bharadwaj, 2000), IT integration capability (Benitez et al., 2018), and IT reconfiguration capability (Pavlou & El Sawy, 2010; Rai & Tang, 2010). In that regard, future research should also study capabilities that focus on the IT-enabled resource, especially concerning its components, structural properties, and renewal.

10 Conclusions

IT benefits is usually short-lived, especially in dynamic environments (Kohli & Grover, 2008; Wade & Hulland, 2004). Apparently, the integration and combination needed to form IT-enabled resources from which organizations derive IT benefits can also constrain the renewal and deployment of IT-enabled resources to address new strategic goals thus cutting short the derivation of IT benefits (Rodon et al., 2011). Drawing on relevant theories, a review of 18 published empirical cases, and an in-depth case study, this study explores the structural properties of IT-enabled resources and how the structural properties enable or constrain their renewal.

The findings suggest that there are three structural properties of an IT-enabled resource, namely, component flexibility, component centrality, and component coupling. The structural properties individually and collectively influence the renewal and deployment of IT-enabled resources. The study extends Nevo and Wade's (2011, 2010) model with the structural properties of an IT-enabled resource and proposes eight propositions that relate the structural properties and organizational capabilities to the renewal of IT-enabled resources. With the emerging demands for new resource combinations (e.g., in pursuance of digital transformation and digitalization), managers can use the findings to guide the formation of IT-enabled resources in ways that sustain the derivation of IT benefits, especially in dynamic environments.

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Appendix A: Published Empirical Cases

Table A1 List of Empirical Cases that were Reviewed

Author	IT-enabled resource	Components	Structural Properties	Renewal
Macredie and Sandom (1999)	IT-enabled workflow	1. Workflow application 2. Several Processes (e.g., workflow, documentation configuration control, document review) 3. Other IT assets (e.g., databases)	1.focal IT asset with high centrality 2.flexible processes 3.inflexible focal IT assets 4.tightly coupled IT assets and processes	Organizational processes were changed through improvisation to make up for the difficulties in changing the focal IT.
Svejvig and Jensen (2013)	IT-enabled accounting processes	1. Focal IT asset (Oracle E-business suite) 2. Accounting processes	1.flexible IT asset 2. IT asset with high centrality 2. inflexible accounting processes 3.tightly coupled IT asset and accounting processes	Tight integration of the focal IT and work processes led to difficulties in upgrade
Azad and King (2008, 2012)	IT-enabled tax administration	1.Focal IT asset (Tax administration IS) 2.Other IT asset (Spreadsheet) 3.Tax administration processes	1.Inflexible focal IT asset 2.Inflexible work processes 3.Flexible other IT asset 4. Tightly coupled work process and focal IT asset 5. loosely coupled work process and other IT asset	Focal IT and work processes were coupled (i.e., loosely linked). Other IT asset was used to perform work process instead of the focal IT asset
	IT-enabled medication administration	1.focal IT asset (medication dispensing system) 2. medication dispensing processes 3. Teams of nurses and doctors (Actors)	1.loosely coupled focal IT and medication dispensing processes 2.focal IT asset with high centrality 3.Inflexible focal IT asset 4. Flexible work processes	Actors change their work processes to make up for the inflexibility in the focal IT (caused by healthcare policy)
Rodon et al. (2011)	IT-enabled transport network	1. focal IT asset (interorganizational IS) 2. Organizations 3. other IT assets 4. transport work processes	1.focal IT asset with high centrality 2.Flexible focal IT asset 3. tightly coupled work process and focal IT 4. inflexible work processes	Changes to tightly couple work processes and focal IT assets and organizations constrained further chance (renewal)
Goh et al. (2011)	IT-enabled clinical documentation	1. Focal IT asset (computerized documentation system) 2. Team of health workers 3. several healthcare processes 4. Other IT assets	1.focal IT asset with high centrality 2.Flexible focal IT asset 3. loosely coupled work process and focal IT 4. flexible work processes	Co-evolution of flexible IT and work processes to meet emerging user performance needs
Lyytinen et al. (2009)	IT-enabled accounting	1. Focal IT asset (an ERP) 2. Work processes (including accounting processes)	1.Flexible IT asset 2.IT asset with high centrality 2.flexible work processes 4. loosely coupled work processes and focal IT 5. tightly coupled IT asset and accounting process	Loosely coupled focal IT assets and work processes enabled change and tightly couple focal IT asset (ledger module) and work process (accounting process) led to efficiency
Seethamraju (2009)	IT-enabled processes	1. focal IT asset (SAP) 2. several organizational functions 3. Several work processes 4. several other IT assets	1.focal IT with high centrality 2.inflexible processes 3.flexible processes 4. tight coupling between focal IT asset and inflexible processes 5. loose coupling between IT asset and flexible processes	Loose coupling between focal IT asset and flexible processes enabled renewal (agility), and tight coupling between focal IT asset and inflexible processes enabled efficiency

Berente et al. (2008), Berente and Yoo (2012)	IT-enabled processes	1. Focal IT asset (SAP) 2. several organizational functions 3. Several work processes 4. several other IT assets (e.g., spreadsheets) 5. Several teams (e.g., project managers, administrators, and researchers)	1. focal IT asset with high centrality 2. inflexible processes 3. tight coupling between focal IT asset and processes 4. loose coupling between IT asset and flexible (improvised) processes	Teams leveraged flexible processes and other IT assets to compensate for tightly coupled processes and an inflexible focal IT asset
McGann and Lyytinen (2008)	IT-enabled supply chain	1. focal IT asset (inter-organizational IS) 2. Organizations 3. other IT assets (e.g., spreadsheets, legacy system) 4. work processes	1. focal IT asset with high centrality 2. loose links between other IT assets (legacy system) and other IT assets and work processes 3. flexible work processes 4. flexible other IT assets 5. tight coupling between focal IT assets and work process	Changes were effected by extending existing work process and other IT assets or by creating new work processes and other IT assets
Drummond (2008)	IT-enabled claims processing	1. A focal IT asset (claim processing application) 2. claims work process 3. improvised processes 4. Other IT asset (e.g., word processing system) 5. Work teams	1. Inflexible focal IT asset 2. flexible work processes 3. Flexible other IT asset 4. Tightly coupled work process and focal IT asset 5. loosely coupled work process and other IT asset	Changes were made by developing loosely linked work processes and other IT assets leading to a decline in performance
Santhanam et al. (2007)	IT-enabled loan processing	1. focal IT asset 2. several functions 3. Work teams (e.g., help desk, portfolio, and project managers) 4. work processes	1. flexible focal IT asset 2. flexible work processes 3. loosely coupled focal IT asset and other IT assets 4. improvised processes	Change wasmade by adapting work processes and focal IT assets and by reconciling and institutionalizing the adaptations.
Schneider et al. (2018)	IT-enabled customer relations manageme nt	1. focal IT asset (cloud-based CRM system) 2. work processes 3. Multiple functions /divisions 4. Other IT assets	1. flexible focal IT asset interface (yet, inflexible workflows) 2. tight coupling between focal IT asset and other IT assets 3. tight coupling between IT asset and work processes 3. high centrality of focal IT asset	Changes to the focal IT asset and the tight coupling between focal IT asset and work processes and other IT assets constrained renewal and derailed performance
Spierings et al. (2017)	IT-enabled work processes	1. focal IT asset (Enterprise system) 2. Work processes 3. Other IT assets (e.g., feral information systems)	1. loosely coupled focal IT and work processes 2. loosely coupled focal IT and other IT assets 3. focal IT asset with high centrality	Other IT assets were used to effect changes and to go around the limitations of the focal IT asset
Baird et al. (2017)	IT-enabled physician practices	1. focal IT asset (electronic health record system) 2. work processes 3. Other IT assets (e.g., lab information system, email) 4. other organizations (e.g., Labs)	1. Flexible focal IT asset 2. loosely linked focal IT asset and work processes 3. Loosely linked focal IT asset and other IT assets	Loose links between focal IT and work process and loosely linked focal IT and other IT (e.g., lab IT assets) made the components evolve discrepantly. Processes were modified to establish tight links between processes, focal IT assets and other IT assets.
Beaudry and Pinsonneault (2005)	IT-enabled banking account manageme	1. focal IT asset (account management system) 2. work teams (e.g., account manager and	1. focal IT asset with high centrality 2. flexible processes 3. flexible focal IT assets	The loosely coupled focal IT asset, work processes, work teams, and other IT assets enabled renewal

	nt	administrators) 3. work processes 4. other IT assets (e.g., email and spreadsheets).	and other IT assets 4. loosely coupled focal IT assets, work processes, work teams, and other IT assets	to address different goals
Orlikowski (1996)	IT-enabled customer service department	1. focal IT asset (incident management system) 2. customer service department 3. work processes 4. work teams	1. flexible focal IT asset 2. loosely coupled focal IT assets, other IT assets, customer service department and work processes and teams 3. flexible work processes	Loose coupling between focal IT asset and flexible processes and teams enabled renewal and co-evolution.
Leonardi (2011)	IT-enabled automotive design	1. focal IT asset (computer simulation application) 2. several departments/ functions 3. work teams (e.g., engineers) 4. other IT assets	1. Flexible focal IT asset 2. focal IT asset with high centrality 3. Flexible work processes and other IT assets.	Flexibility of focal IT asset and work processes allowed for renewal through extension of work process and the focal IT asset
Davidson and Chismar (2007)	IT-enabled physician order entry	1. focal IT asset (order entry systems) 2. clinical departments 3. work teams (e.g., nurses, doctors, pharmacists) 4. work processes 5. other IT assets (e.g., pharmacy system, and laboratory system)	1. Inflexible focal IT asset 2. flexible work processes 3. inflexible work processes 3. focal IT asset with high centrality 4. Flexible other IT asset 5. Tightly coupled work process and focal IT asset 6. loosely coupled work process and other IT assets	Change was effected by adapting flexible work processes and other IT assets to compensate for the inflexibility of the focal IT asset and inflexible work processes tomorrow

Appendix B: Information on Empirical Case Study

Table B1. List of participants for study on the Structural Properties of IT-enabled Resources

Pseudonym	Duration	Gender	Description
Res1	31:41	Female	Administrator and developer (case university)
Res2	45:42	Male	Lecturer / community developer
Res3	55:50	Female	Consultant / Community developer
Res4	47:54	Female	Manager (case university)
Res5	47:12	Male	Lecturer
Res6	36:35	Male	Teaching Assistant
Res7	34:37	Female	Lecturer
Res8	40:02	Male	Lecturer
Res9	33:18	Female	Lecturer
Res10	18:05	Female	Student
Res11	44:36	Female	Lecturer
Res12	39:52	Female	Manager (case university)
Res13	48:46	Female	Lecturer
Res14	51:26	Female	Lecturer
Res15	26:10	Male	Lecturer
Res16	48:04	Male	Lecturer
Res17	49:13	Male	Lecturer
Res18	30:07	Male	Student
Res19	20:53	Female	Student
Res20	20:10	Female	Student
Res21	28:16	Female	Student
Res22	26:45	Male	Lecturer

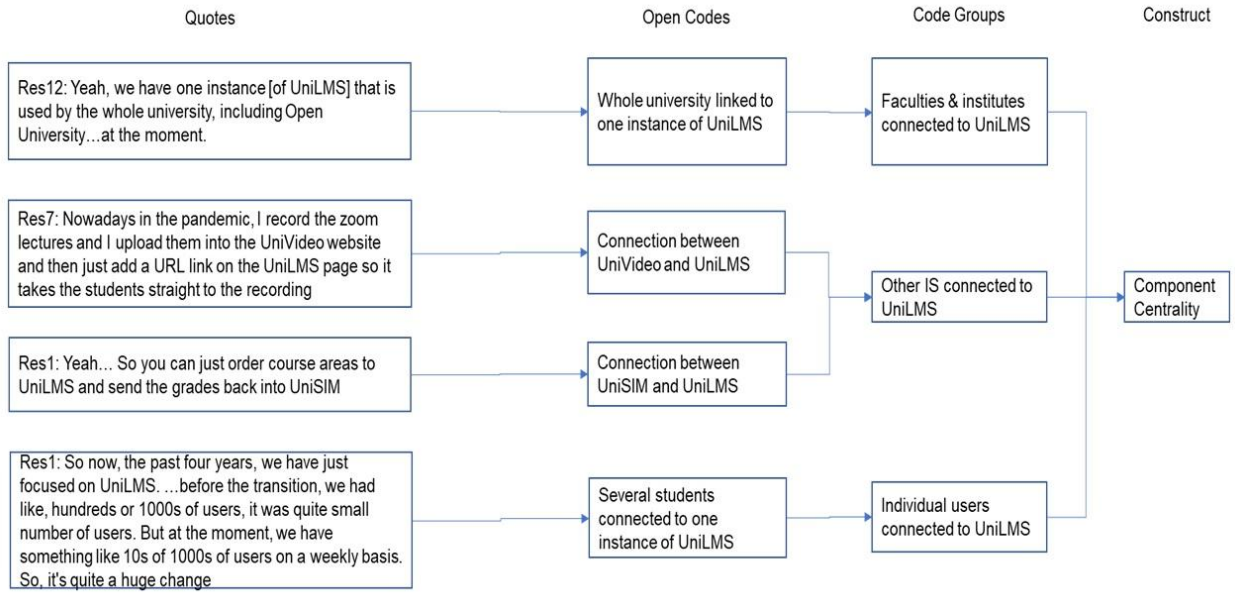

Figure B1. Data Analysis (Component Centrality)

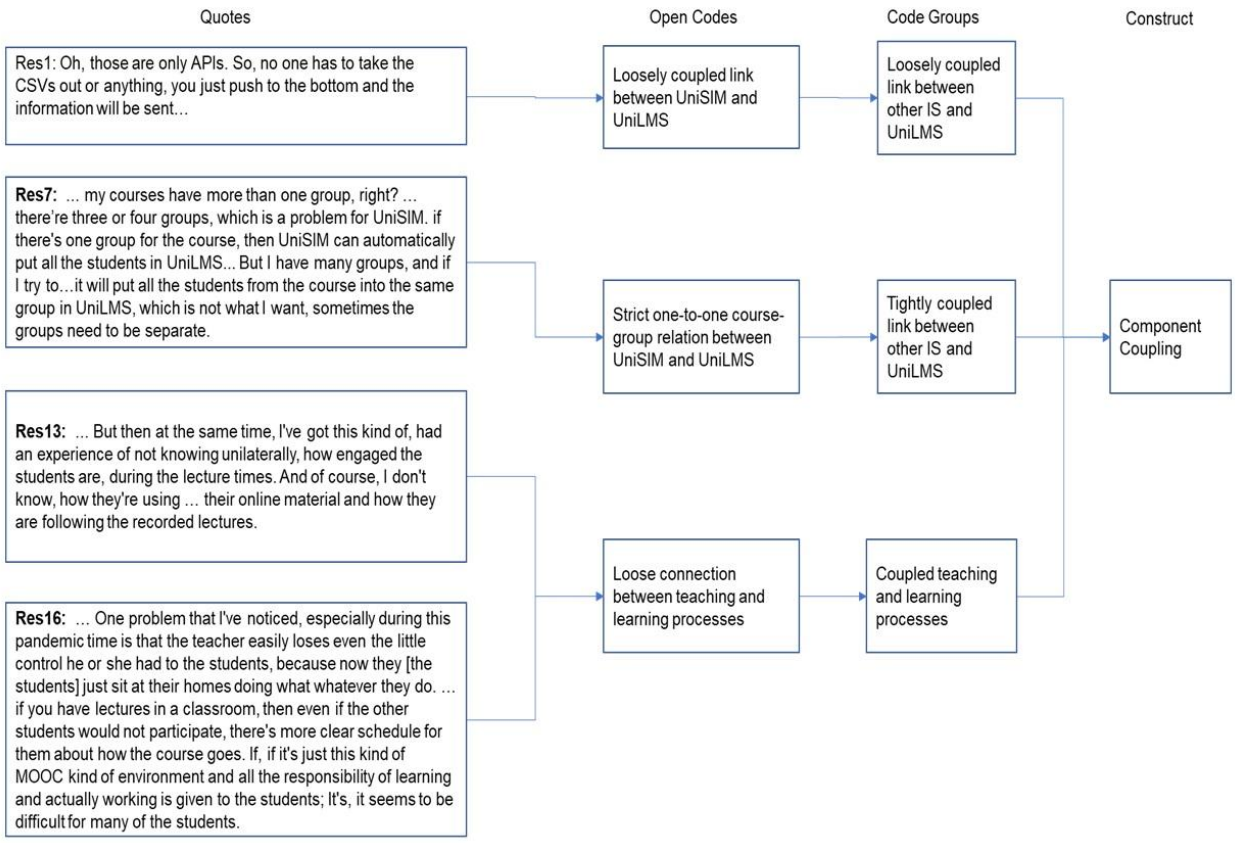

Figure B2. Data Analysis (Component Coupling)

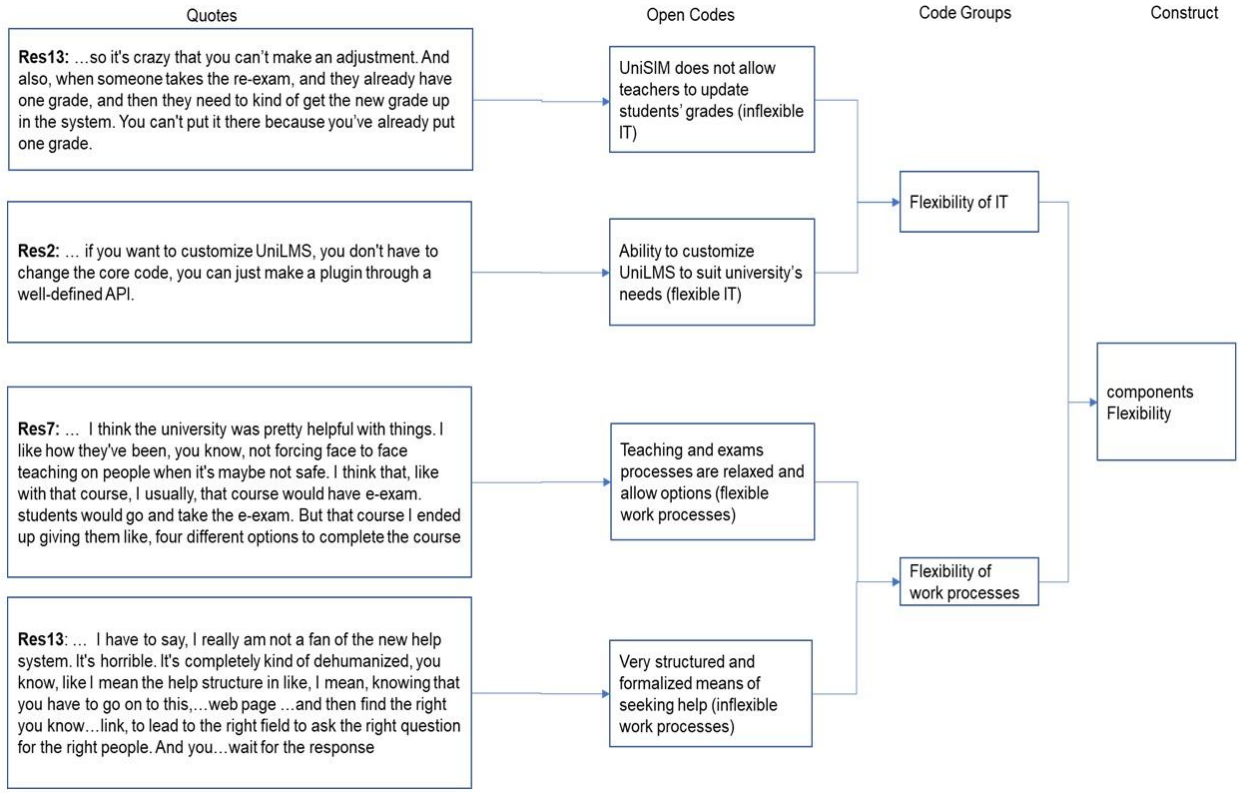

Figure B3. Data Analysis (Component Flexibility)

About the Authors

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Ari Hirvonen serves as chief digital officer of the University of Jyväskylä, with responsibility for digital strategy, IT, enterprise architecture and information security. He also serves as president of the Finnish Universities CIO (FUCIO) network and holds several national responsibilities in higher education digitalisation. Previously, he has worked as a consultant and led consulting businesses in business, enterprise architecture and programme management consulting, and served as chief technology officer in the largest IT service company in the Nordic countries. Ari Hirvonen holds an adjunct professorship of enterprise architecture and has also served as a lead consultant in the development of Finland’s national enterprise architecture methodology.