COUNTERFACTUAL DEPENDENCE, BOUNDARY AND RESOURCE DEPENDENCE

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ABSTRACT

This study employs counterfactual dependence to explore boundary interactions in resource dependency research. Using set-theoretic operations—union, intersection, and complement—we examine how boundaries evolve when interdependence precedes and shapes non-equity relationships. We propose that when interdependence changes non-equity relations, counterfactual dependence adjusts boundary interactions at union (dichotomy) and intersection (clopen) operations. Additionally, counterfactual dependence facilitates consensus through transitive causation while maintaining dissensus, influencing boundary interactions at union. In cases of persistent dissensus caused by intransitive causation, counterfactual dependence elucidates the complement at union. This research highlights the importance of causal (counterfactual) resource dependence and set theory in advancing the understanding of boundary interactions in international business research.

Keywords: Boolean algebra, causal (counterfactual) dependence, interdependence, non-equity, set-theory.

INTRODUCTION

Resource Dependence Theory (RDT) is a key concept in international business literature. It suggests that interdependence, established through direct relationships, represents an interaction dependent on resources (Drees & Heugens, 2013; Emerson, 1962; Pfeffer & Salancik, 1978; Thompson, 1974). In this context, interdependence serves as the antecedent, while non-equity interactions emerge as the consequent, forming a causal resource dependence. Initially, international business actors (e.g., firms and resource holders) establish interdependence. Non-equity interactions may follow due to deliberate

restrictions or failure to reach consensus on more extensive equity arrangements. This approach allows actors to access critical resources without long-term commitments, retaining autonomy before committing to equity-based interactions (Pfeffer & Salancik, 2003, 1978).

Equity-based interactions are distinct from non-equity ones, resembling arm's-length market exchanges while preserving autonomy (Contractor & Lorange, 1988). Restrictions help prevent misuse of interdependence and align with the logic of consensus. In this study, consensus is examined in relation to intellectual property rights (IPRs) and protected designation of origin (PDO) restrictions, highlighting the vulnerabilities that arise in the absence of specific resources (E.C, 2012, 2014). IPRs and PDOs provide exclusive rights and legal protection to intellectual property owners (Prud'homme & Tong, 2024). It is essential to note that when interdependence consents to restrictions, the relationship may extend without weakening resource commitments. However, if interdependence contributes to or directly alters non-equity interactions, defining the boundaries of the relationship becomes more challenging.

Using set theory (Boolean logic), the researcher define boundaries through direct relationships, adhering to Occam's razor principle. Sets enable comparative interactions (Ragin, 1987, 2000) and help explain causation (counterfactual dependence) which is essential for understanding resource dependence (Collins et al., 2004; Lewis, 1970, 1973). As a novel contribution to academic research, we ask: How does boundary evolution unfold within resource dependence when interdependence precedes non-equity and subsequently changes the latter relationship? We propose the following: When interdependence alters non-equity, counterfactual dependence (dichotomy) adjusts boundary interactions at the union operation. Similarly, counterfactual dependence (clopen) adjusts the boundary at the intersection operation. Additionally, counterfactual dependence (transitive causation—maintaining dissensus) adjusts the boundary at the union operation. In cases of persistent dissensus due to intransitive causation, counterfactual dependence explains the complement at the union operation.

CASE METHOD

This study explores firms strongly influenced by resource dependence (Aldrich & Mindlin, 1978) using an interview-based case-study approach. Data is derived from empirical PhD research on an archetypal industry that ensures resources genuinely originate from a specific region using traditional methods. This status guarantees authenticity while preserving the unique qualities of these resources, which are intrinsically linked to their geographical origin. In turn, this helps safeguard national traditions and promotes cultural pride (Mandrinos, 2014). Standardisation within this context benefit relationships by enforcing rigorous standards, which can lead to increased interdependence. The study assumes that firms are significantly affected by the interdependence of their resource holders in non-equity relationships. Key cases were selected within a specific country (Gomes et al., 2016; Nersessian, 2008), following Geddes's (2003, p. 117) definition of single-country studies aimed at explaining specific outcomes or illustrate specific changes. According to Geddes (2003), single-country studies are instrumental in explaining outcomes or highlighting specific changes within a distinct context. By focusing on a single country, this research delves deeply into its unique socio-economic, cultural, and institutional landscape, providing rich and detailed insights that may be diluted in broader, multi-country studies. Similarly, conducting research within a single country allows for a more controlled study environment, reducing external variables that could otherwise confound the results. This focus helps strengthen the study's internal validity and reliability, as findings can be more directly attributed to the factors being studied. Additionally, a single-country focus enables a thorough understanding of

the local regulatory environment, industry standards, and market dynamics leading to more precise analysis and interpretation (Gomes et al., 2016; Nersessian, 2008).

The Hellenic Milk Organisation database provided a sample of nine firms, ensuring diversity by including staff from various levels (Regnér & Edman, 2014). Interviews were recorded, transcribed, translated, and analysed. The interview-based case-study approach facilitates an in-depth exploration of the complex phenomenon of resource dependence. By conducting interviews, the study captures detailed insights and understanding of how firms navigate resource dependence and interdependence. Interviews provide a direct means to capture non-equity relationships, as they enable respondents to articulate their experiences and strategies for managing resource dependencies. This method yields rich data that reveal the complex interactions between firms and resource holders.

Table 1

Profile

Firm	Age (Years)	Size	Status	Participant	Location
α1	30+	Medium	Family Business	Owner	Head Office
α2	30+	Medium	Family Business	Export Manager	Head Office
β1	60+	Large	Corporation	Export Manager	Remotely
β2	60+	Large	Corporation	Export Economic Director	Head Office
γ1	30+	Medium	Corporation	Export Manager	Head Office
γ2	30+	Medium	Corporation	Export Sales Director	Head Office/ Remotely
δ1	50+	Large	Family Business	Export Director	Head Office
δ2	50+	Large	Family Business	Export Department	Head Office
ε1	50+	Large	Corporation	Export Manager	Head Office/ Remotely
ε2	50+	Large	Corporation	Export Area Manager	Head Office
ε3	50+	Large	Corporation	Export Area Manager	Head Office
ζ1	90+	Medium	Corporation	Export Director (IBDM)	Remotely
ζ2	90+	Medium	Corporation	Export Area Manager	Head Office/ Remotely
η1	60+	Large	Corporation	Marketing Manager	Head Office
η2	60+	Large	Corporation	Export Area Manager	Head Office
η3	60+	Large	Corporation	Bulgaria Market Director	Remotely
η4	60+	Large	Corporation	USA Market Director	Remotely
θ1	30+	Medium	Family Business	Export Manager	Head Office
θ2	30+	Medium	Family Business	Export Area Manager	Head Office
θ3	30+	Medium	Family Business	Export Department	Head Office
ι1	30+	Large	Corporation	General Director / Consultant	Head Office
ι2	30+	Large	Corporation	Romania Market Director	Remotely
ι3	30+	Large	Corporation	Export Manager	Remotely
ι4	30+	Large	Corporation	Export Area Manager	Head Office
ι5	30+	Large	Corporation	Export Department	Head Office

To ensure accuracy, several validation strategies were employed (Cuervo-Cazurra et al., 2020). Context-dependent validity was strengthened by the researcher's prior national and international experience (Welch & Piekkari, 2017). Construct validity was established through triangulation, incorporating interviews, press releases, newspaper articles, annual reports, and observations (Patton, 2002; Yin, 1984). Reliability was reinforced by developing a case-study protocol and database using a table-shell layout (Miles & Huberman, 1994; Yin, 2009). Additionally, cross-case comparisons enhanced generalisability and trustworthiness (Eisenhardt, 1989; Yin, 1984). The matrix technique was applied for data extraction and analysis, emphasising figurative meanings and data flow (Miles & Huberman, 1994). This methodological approach aids in understanding resource dependence by examining the interplay between restrictions, interdependence, and non-equity interactions, particularly when the boundaries between phenomenon and its context are not clearly evident (Yin, 2009, p. 18).

THEORY AND DOMAIN

Resource Dependence

Resource dependence theory examines how entities must obtain external resources to survive, often relying on sources they cannot fully control. In essence, the theory posits that firms are influenced by their external resource environment, including interdependencies with other entities. Resource dependence explains interdependence as a relationship—either short- or long-term—regulated through formal contractual mechanisms and restrictions. To manage these interdependencies and promote consensus, non-equity relationships are structured around the core, nationally certified resources (Barney & Hesterly, 2015; Drees & Heugens, 2013; Hillman et al., 2009; Peng et al., 2009). Location-bound isomorphism institutionalises specific criteria and structures, ensuring autonomy in securing and utilising these resources (DiMaggio & Powell, 1983; Meyer & Rowan, 1977, p. 346; Thompson, 1974). These structures and procedures are designed to manage resource dependence while maintaining autonomy despite differing interests (Greenwood et al., 2011; Heese et al., 2016; Raynard, 2016; Thornton, 2002). Therefore, even when parties act independently, they must adhere to the same institutional restrictions. For example, resource holders' interdependence manifests in non-equity relationships when they engage in contractual agreements to secure a stable supply of essential resources. These contracts formalise expectations and obligations, reducing uncertainty and dependency risks. Hence, resource holders must align their operations with firms to ensure continuous production and distribution, creating a network of interdependent relationships based on shared institutional restrictions.

Nationally Certified Resources

Firms and resource holders engage in an exclusive, location-bound dependence, as firms operating within approved production facilities for milk and dairy products (such as Feta) must comply with Regulation 853/2004 (E.C., 2004). The reliance on core, nationally certified resources and adherence to PDO restrictions define the exclusive IPRs within non-equity relationships. These restrictions validate guidelines, and contractual structures that *standardise* direct relationships. As one respondent explained: *"[…] if you do not have the essential resources, you cannot do anything. The first level is sheep milk, with the ratio to be kept every time it characterises the product and the firm's recognition directly tied to the signed contracts"* (ι2). Similarly, stringent procedures govern these direct relationships: *"[…] we cannot have any milk, any quality from any area, showing that we are limited to specific standards"* (θ3). This exclusivity is further reinforced by PDO regulations: *"[…] Feta only Greece can produce; that is, anyone who makes cheese with Feta characteristics of 70% or 30% sheep and goat milk, and all of the other characteristics highlighted by the PDO regulation, yet it is produced in another country, cannot call it Feta"* (β1). *"[…] Feta is made of sheep's and goat's milk because this milk does not exist throughout the year; it starts roughly in December*

and ends in August. Hence, you need to cover your whole production forecast during this period to adequately cover the period you don't produce Feta" (ε1). Additionally, direct relationships extend beyond resource procurement. Firms actively support resource holders by providing technological advancements and immediate assistance when needed: *"[...] support the resource holders by offering (firm) new technologies, and when they need it immediate assistance to improve both the quality and quantity of the resources"* (η2). *"[...] the raw material must come from Greece and cannot be different. If someone imports foreign milk from another country, it cannot produce Feta"* (η4).

Nationally Non-Certified Resources

While core (nationally certified) resources form the foundation of non-equity relationships, peripheral *(nationally non-certified)* resources may sometimes be absorbed, revealing vulnerabilities in safeguarding these relationships. Although interdependence and non-equity are subject to the same restrictions as certified resources, deviations occur. For instance, *"[...] it is determined by international standards that adding cow's milk to Feta is prohibited, yet, there are firms using cow's milk without the proper production practices"* (η4). As one respondent noted, *"[...] many times, unscrupulous individuals are repeatedly caught because they label a cheese feta without following the production procedures for Feta"* (θ2). Another stated, *"[...] firms paradoxically and absurdly have found ways to sell very cheap Feta. What they do, I am not aware of. But how is it possible for a company like ours to sell Feta at lower prices? We have reached economies of scale, and everything is assessed and estimated. Honestly, I don't know what they do. I assume, but I cannot say it. I think they don't use the right raw material which of course is against the regulation"* (ι5). These accounts demonstrate that while interdependence and non-equity co-exist, non-equity is not always the direct recipient in the relationship. Instead, interdependence acts as the antecedent (cause), influencing changes in the non-equity relationship (effect). When firms incorporate nationally non-certified resources, they signal a weakened commitment to established restrictions, ultimately affecting the stability of these relationships and diluting resource commitment across industry.

Foreign Non-Certified Resources

Similarly, dependence on external *(foreign non-certified)* resources disrupts regulatory restrictions, leading to a mismatch in the non-equity relationship. This issue arises when competitors manage to maintain low prices while still claiming to produce authentic PDO Feta. As one respondent observed, *"[...] Other competitors, I'm not sure how they can maintain low prices while claiming to have authentic PDO feta. For example, there is a price difference if someone uses foreign milk instead of Greek milk"* (γ1). Legal consequences further illustrate this challenge. In one case *"[...] 'Vassiliadis' committed an illegal act and was fined one hundred thousand (euros). Why? Because instead of using Greek milk, they used imported milk or milk powders"* (γ2). The inclusion of non-certified resources—such as foreign milk, imported milk, or milk powders—directly contradicts the fundamental principles of certified output. This highlights that interdependence and non-equity do not always operate concurrently. In this context, non-equity is not the direct recipient in the relationship; rather, interdependence serves as the antecedent (cause), driving changes in the non-equity relationship (effect). Dependence on external *(foreign non-certified)* resources alters the relationship dynamics, weakening regulatory restrictions and affecting boundary maintenance within the industry.

Consensus and Dissensus

Engaging in interdependence with peripheral and external resources shows a distinct relationship with regulatory restrictions. This interaction highlights the role of dissensus in limiting the influence of core resources, which, in turn, significantly influences the relevance of boundaries. When interdependence, contributes to or drives changes in non-equity relationships, dissensus regarding restrictions signals a

potential or imminent demise of these relationships (Vasudeva et al., 2013). This places non-equity relations in a vulnerable position, increasing the risk of termination. As a result, the inability to sustain interdependence—where interdependence serves as the antecedent—further confirms the nature of the direct relationship. In short, restrictions shape interdependence. While consensus facilitates interdependence, dissensus complicates its establishment (Gong & Janssen, 2012; Powell & Colyvas, 2008; Scott, 2001). Consensus and dissensus function as opposing forces that influence strategic relationships (Dess & Origer, 1987; Doz et al., 2000; Treviño & Doh, 2021). Hence, in interactions where restrictions are subject to dissensus, relational expectations (Oliver, 1991, p. 162) can introduce complexity, making it difficult to define boundary spans (Floyd & Jane, 2000; Oliver, 1991; Whelan, 2013). This dynamic clarifies that direct relationships and restrictions are shaped by interactions involving both consensus and dissensus (Dahlander et al., 2016; Domínguez et al., 2022; Zhao et al., 2017).

Elements

When examining boundaries within resource dependence, restrictions, interdependence, and non-equity can interact in various ways, forming unions, intersections, or complements. This study uses unary and binary elements to model these interactions (Burris & Sankappanavar, 1981; Fritz, 2021), simplifying resource dependency by applying Boolean operations. Data related to restrictions, interdependence, and non-equity interactions are analysed using a binary framework, where true (1) and false (0) indicate equivalence. To determine restrictions, we consider the significance of PDO and IPRs. Interdependence is examined through procedures and control, which are crucial for understanding coordination and collaboration in resource utilisation. Non-equity relationships are defined by contracts and standards, which define the terms, conditions, and specifications governing resource exchanges.

In this system, restrictions and interdependence often occur simultaneously with non-equity relations through union, intersection, and complement operations. While interdependence aims to explain resource dependency, elements like procedures and control add complexity, allowing non-equity relationships to manage resources independently. This distinction highlights that interdependence and non-equity interactions shape resource dependence in different ways.

When elements of interdependence (procedures and control) interact with elements of non-equity (contracts and standards), they influence the evolving domain and affect boundary spanning. This dynamic presents a research opportunity through a set-theoretic framework, linking causal (counterfactual) dependence to key elements and demonstrating how specific causal relationships impact the evolving resource dependence landscape (Durand & Vaara, 2009: 1250).

ANALYSIS

To understand how elements interact within resource dependence, interdependence and non-equity form distinct sets, enabling the analysis of different relationships through various operations. Set theory is inherently involved in constructing algebraic relations (Givant & Halmos, 2009; Halmos & Givant, 1998). By systematically examining these relational sets, it becomes feasible to effectively identify the existence of fuzzy relations. In this study, each relation is given alphabetic substitutions, with each containing two binary elements to facilitate operations:

- Restrictions (R): $R(q_{IPRs}; p_{PDO}) - R(q, p)$
- Interdependence (I): $I(d_{procedures}; c_{control}) - I(d, c)$
- Non $-$ equity (N): $N(t_{contracts}; s_{standards}) - N(t, s)$

Operations are defined as follows:

- Union (∪): Represents 'one, the other, or both.'

- Intersection (∩): Represents 'both or neither.'

- Complement (′): Represents 'the opposite of a given statement.'

These operations specify the dependent relationships. Our analysis applies a set and element logic, employing *union*, *intersection*, and *complement*, as well as *join* and *meet* operations. The union (join) operation occurs when two elements combine, whereas the intersection (meet) operation highlights their commonalities. Essentially, the join operation unites sets, while the meet operation signifies their intersection. Additionally, we use the *false* and *true* inference forms $(0, 1)$ to demonstrate how 0 and 1 satisfy axiomatic conditions (see Table 1). This study utilises unary and binary relations based on the previously assigned alphabetic substitutions to examine sets in relation to causal (counterfactual) dependence.

Operations

A set, denoted as X, is defined together with two binary operations (∪, ∩) and a unary operation (′), as well as the *false* and *true* inference forms $(0, 1)$, which satisfy a set of conditions (see Table 1). The universal set X represents resource dependency interactions, where interdependence—whether supporting or opposing institutional restrictions—contributes to or influences the emergence or alteration of a non-equity relation. This analysis uses binary sets based on the principle that all the laws in Table 1 hold true within a two-element Boolean algebra framework (Givant & Halmos, 2009, p. 129).

Table 2

Axioms

Axioms		Information
$0' = 1, \ 1' = 0$	Complement law	This Boolean equation forms the complement of 0 and 1.
$p \wedge 1 = p, \quad p \vee 0 = p$	Identity law	This Boolean equation shows 'p' is identical with itself.
$p \wedge p' = 0, \quad p \vee p' = 1$	Complement law	This Boolean equation is a dual that results from interchanging 0 and 1 and at the same time interchanging ∧ and ∨.
$(p')' = p$	Double complement	This Boolean equation has a 'not' within a 'not' cancelling each other out.
$p \wedge p = p, \quad p \vee p = p$	Idempotence law	This Boolean equation results from the ∧ 'p' operation can be carried again and again without changing the result.
$(p\,f) \vee (p'\,u) \vee (f\,u) = (p\,f) \vee (p'\,u)$	Consensus law	This Boolean equation reduces complexity in the procedure.

Sets

All subsets of the universal set X are interconnected through three operations, union ($\cup$), intersection ($\cap$) and complement ($'$). Union ($I \cup N$): The union of sets I (Interdependence) and N (Non $-$ equity) consists of elements that belong to either I or N. Using set builder notation, and taking $d_{procedures}$ as an example, the idempotent law (see Table 1) as:

$$I \cup N = d : d \in I \text{ or } d \in N$$

This means that $I \cup N$ includes all elements d that are either in the interdependence set I *or* in the non-equity set N. Intersection ($I \cap N$): The intersection of I and N consists of elements that are present in both sets. Again, applying the idempotent law (see Table 1) as:

$$I \cap N = d : d \in I \text{ and } d \in N$$

This means that $I \cap N$ contains only the elements d that belong to both the interdependence set I and the non-equity set N. Complement: The complement of a set consists of elements that do not belong to that set: I'—The set of elements not in interdependence set I. N'—The set of elements not in non-equity set N. R'—The set of elements not in restrictions set R. Additionally, the empty set ($\emptyset$) contains no elements.

Union and Causal Dependence

In set theory, the union operation combines sets to form a new set containing all elements from both. While union does not explicitly embody causal dependence, it can conceptually align with it in specific contexts. Causal dependence typically describes the connection between a cause and its effect, whereas union is a basic set operation centred on merging elements. In this study, however, union represents the causal dependence between two sets—interdependence (I) and non-equity (N)—since their elements belong to either or both sets. Specifically, when core resources *(nationally certified)* are dependent on PDO restrictions, which are intricately linked to intellectual property rights (IPRs), standardised *procedures* for *controlling* and adopting *contracts* emerge to regulate direct relationships. Under these conditions, *procedures and control* mechanisms blend with *contracts and standards,* forming the union $I \cup N$. Conversely, when peripheral resources *(nationally non-certified)* are involved, despite procedures and control mechanisms being on the periphery, interdependence contributes to or drives the change of the non-equity relationship within the union.

To refine the analysis of interdependence and non-equity, we apply the complement operation (I') to examine how the union relationship is structured. Since interdependence influences changes in non-equity relations, elements such as procedural mechanisms ($d_{procedures}$) and control structures ($c_{control}$) are found in either the interdependence set I *or* the non-equity set N. When peripheral resources are involved, the elements of $d_{procedures}$ and $c_{control}$ strengthen dependence, whereas their complements (which hold opposing meanings) hinders dependence. This duality allows for a temporal arrangement, where interaction within the union operation can be modulated or even avoided. Because interdependence and non-equity interactions are conditioned by real-time factors, they align with temporal logic (Fisher, 2011; Prior, 2003), contradicting frameworks where interactions are flexible and governed by modal logic (Hughes & Cresswell, 2001; Prior, 2003).

Thus, interdependence defined by restrictions within the union operation—but without lasting commitments—corresponds to temporal arrangements that permit alterations over time. In the context of temporal logic, *procedural control* mechanisms can simultaneously hold both *true* and *false* values. This means that even when interactions change, the complement of interdependence (I') may coexist with interdependence (I). Since interdependence (I) and non-equity (N) belong to the universal set X, a subalgebra of resource dependency, denoted as B_I represents situations where interdependence and non-equity interactions occur simultaneously. Specifically, when interdependence (I) is a subset of non-equity (N):

$$B_I : I \subseteq N \text{ and } I.$$

In this formulation, B_I represents the subset I of N, combined with the *false* and *true* inference forms $(0, 1)$—a dichotomy. The false (0) and true (1) inference forms demonstrates that, for example, if $d_{procedures}$ is an element of I ($d \in I$), then its complement $d'_{non\ certified\ procedures}$ is also an element of I ($d' \in I$) such that:

$$1 = d \lor d' \in I \text{ with } 0 = 1' \in I.$$

This inference structure shows that when the non-equity set N is not in the interdependence set I, the relative complement I' facilitates interdependence and non-equity interactions. This view suggests that in a union operation, non-equity relations enable exchanges when the *false* and *true* inference forms of the interdependence are temporally defined. Furthermore, this framework demonstrates that interdependence and non-equity coexist, with changes in the non-equity relationship driven by interdependence. Here, non-equity is not merely a passive recipient in this process but part of an interactive dynamic.

Proposition 1. In resource dependency, when interdependence drives changes in the non-equity relationship, a counterfactual dependence (dichotomy) adjusts the boundary interaction within the union operation.

Intersection

In set theory, the intersection operation identifies elements shared between sets. In our discussion, focusing on the intersection ensures consistency as we consider interdependence I and its complement I' represented by $d_{procedures}$ and $d'_{non\ certified\ procedures}$ respectively. Within interdependence, consenting to restrictions without making lasting commitments characterises the interaction. However, when interdependence is disjoint from non-equity, it limits interaction and aligns with temporal logic. Temporal interaction enables resource dependence while preserving the flexibility for independent actions, contrasting with modal logic, where non-equity driven interactions, grounded in contractual obligations and standards, necessitate stronger commitments. By distinguishing between temporal (changes over time) and modal (necessity-based) logic, we gain insight into the resource dependence framework. Interdependence, characterised by its adaptability over time, contrasts with non-equity, which mandates well-defined, contractually bound relationships. While interdependence permits autonomy in engagement, non-equity requires a structured relationship tied to contractual standards.

An intersection operation satisfies its definition when two sets share common elements, signifying joint consideration. Here, the complement of the interdependence set includes the non-equity set.

Specifically, if the interdependence complement I' contains $d'_{non-certified\ procedures}$ and $c'_{non-certified\ control}$, then no elements of I exist in N, rendering I' closed.

$$I'^{-} \subseteq I'$$

This suggests that if the *procedures governing* interaction are absent from I', then interdependence cannot belong to the set containing non-equity. Consequently, interdependence becomes disjoint from non-equity, rendering it open. When interdependence is open and its complement is closed, the closure of the complement equals the complement itself:

$$I'^{-} = I'.$$

Since interdependence and its complement differ ($I' \neq I$), the boundary of interdependence is defined by the difference between the closure of its complement and interdependence itself:

$$I'^{-} - I.$$

Interdependence intersects with the closure of its complement if this closure also intersects with the interdependence closure:

$$I'^{-} \cap I^{-}.$$

From a more detailed perspective, if $d'_{non-certified\ procedures}$ in I' belongs to the intersection of the closed set, this intersection includes non-equity:

$$d' \in I' : d' \in N.$$

Likewise, the closure of the interdependence complement I'^{-} intersects with the closure of interdependence I^{-}:

$$I'^{-} \cap I^{-}.$$

A key inference here is the concept of a clopen set—one that is both closed and open simultaneously. This counterfactual dependence challenges the standard complement law, which states that the intersection of a set and its complement is empty ($I' \cap I = \emptyset$). Instead, it emphasises that the intersection between interdependence and its complement is distinct, prompting a closer examination of its implications. Under temporal logic, interdependence adjusts to non-equity by incorporating elements that belong to both sets. Real-time interactions align with temporal logic (Fisher, 2011; Prior, 2003), whereas flexible interactions governed by modal logic (Hughes & Cresswell, 2001; Prior, 2003) introduce a different dynamic. The simultaneous occurrence of interdependence and non-equity underscores their interrelation, reinforcing the relevance of shared elements at the intersection. Considering all sets under discussion, interdependence intersects with every clopen set due to *procedural controls* governing interaction. In other words, procedural interaction belongs to the closure of every set in X, revealing that locality occurs at the intersection.

Proposition 2. In resource dependence, when interdependence is responsible for altering the non-equity relationship, a counterfactual dependence (clopen) adjusts the boundary interaction at the intersection operation.

Complement

In set theory, the complement operation denotes the set of elements that do not belong to a given set. In the context of resource dependence (X), the complement (R') in interdependence (I) and non-equity (N) can be either *relative* or *absolute,* including all elements not in R. Following temporal logic, neither interdependence nor non-equity is entirely separate from consensus, yet their relationship exhibits counterfactual dependence, where their relationship depends on *false* or *true* inference $(0, 1)$. Actors seeking to access essential resources may agree to restrictions without making long-term commitments, as previously discussed regarding peripheral and external resources.

To illustrate the complement operation, we refer to the consensus law (see Table 3) which operates within the causal resource dependence framework of restrictions, interdependence, and non-equity:

$$(R\ I) \cup (R'\ N) \cup (R\ N) = (R\ I) \cup (R'\ N)$$

To establish consensus, we employ a truth table (see Table 3) to identify interactions that can be consistently replaced by *false* and *true* inference forms represented by 0 and 1. Unlike fuzzy logic (Treadwell, 1995), which considers numerical intervals, this approach follows Ragin (1987, p. 2000), who describes differences based on direct relationships and causal consistency. In this view, truth tables are central to counterfactual analysis.

Table 3

Truth Table

R (restrictions)	I (interdependence)	N (non − equity)	$(R\ I) \cup (R'N)$ $\cup (R\ N)$	$(R\ I)$ $\cup (R'\ N)$
0	0	0	0	0
0	0	1	1	1
0	1	0	0	0
0	1	1	1	1
1	0	0	0	0
1	0	1	0	0
1	1	0	1	1
1	1	1	1	1

Causal logic is particularly useful for explaining the complement operation based on truth and falsehood in consensus. Within causal dependence, changes in one set trigger changes in another, meaning the consensus operation produces four distinct complement combinations to sustain *true* inference at the union level. For instance, if all sets are *true* and consensus is *true,* causation is transitive[1] within causal

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[1] Transitive relation occurs when for instance R is related to I, and I is related to N, then R is related to N.

resource dependence. Conversely, if restrictions and interdependence are *true*, but non-equity is *false*; consensus remains *true*, but causation is transitive without causal dependence. Understanding transitive causation is essential in analysing resource dependence when restrictions, interdependence, and non-equity operate through counterfactual dependence. Counterfactual reasoning shows that an effect depends on its cause, even if the cause did not actually lead to the effect. Simply put, causal dependence implies causation, where causation serves as a cause for dependence. However, the reverse is not necessarily true, as seen in the simultaneous occurrence of interdependence and its complement. This distinction underscores the idea that not all instances of resource dependence require a direct antecedent–consequent relationship. In complement relations, causation is transitive, whereas causal dependence is not. When causation occurs without causal dependence, counterfactual dependence determines a specific locality that adjusts interaction at the boundary.

Proposition 3a. In resource dependence, when interdependence alters the non-equity relationship and consensus is attained through transitive causation, a counterfactual dependence in complement relations adjusts boundary interactions at the union.

When both restrictions and interdependence are *false* but non-equity is *true,* consensus remains *true,* indicating that interdependence occurs simultaneously with its complement. In this scenario, counterfactual dependence enables interactions within a designated boundary. Interdependence and non-equity depend on restrictions, as interdependence occurs only if non-equity has already taken place (isomorphic relationship). However, when restrictions are *false* while both interdependence and non-equity are *true,* consensus is still maintained*,* showing that restrictions, though not an inclusive standard, serve as a counterfactual element related to the complement. While a complement represents a contradictory statement, counterfactuals challenge restrictions (isomorphic) by sustaining dissensus without negating its influence when consensus is ultimately achieved, thereby modifying interactions at the boundary. The interplay between consensus and dissensus creates a logical contradiction, where consensus shifts from causal to counterfactual resource dependence in a temporal manner. Consensus introduces an element of fuzziness that helps define the boundary while also defining the span when interdependence is constrained by dissensus.

Proposition 3b. In resource dependence, when interdependence alters the non-equity relationship and consensus is attained by sustaining dissensus, a counterfactual dependence of a complement relation adjusts boundary interactions at the union operation.

In the context of causal dependence, the consensus operation introduces four distinct complement relations aimed at accommodating the *false* inference form. When restrictions, interdependence, and non-equity are all *false*, the expected consensus is also *false*, and the complement demonstrates both causation and causal dependence. However, when restrictions and non-equity are *false*, but interdependence is *true*, consensus remains *false*, maintaining dissensus when causation is intransitive[2]. From the perspective of intransitive causation, *false* restrictions correspond to *false* non-equity but do not necessarily imply a direct causal link to interdependence when it is *true*. This indicates that causal dependence involves interactions that do not directly align with a *false* consensus. The presence of interdependence, being subject to *false* non-equity, does not indicate a direct relationship, highlighting a shift from causal to counterfactual resource dependence, where dissensus is sustained when both

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[2]Intransitive relation occurs when R is related to I, and I is related to N, then R is not related to I yet relates to N.

restrictions and consensus are *false*. Thus, the logic of intransitive causation, in which both *true* and *false* inference forms contribute to a *false* consensus, highlights the relevance of counterfactual dependence. This becomes particularly evident in cases where either (1) restrictions are *true*, while interdependence and non-equity are *false*, or (2) when restrictions and non-equity are *true* while interdependence is *false*. In such scenarios, a *false* consensus leads to the simultaneous occurrence of interdependence and its complement, suggesting that when dissensus persists due to intransitive causation, counterfactual dependence provides an explanation for this operation.

Proposition 3c. In resource dependence, when interdependence alters the non-equity relationship and dissensus is sustained by intransitive causation, counterfactual dependence plays a pivotal role in explaining the complement at the union operation.

CONCLUSION

This study addresses a gap in the understanding of boundary interactions within resource dependency research. By incorporating causal (counterfactual) dependence, we explore new paths for conceptual and empirical enquiries in international business. Following Durand and Vaara (2009) on counterfactuals, our analysis proceeds in three steps: prediction, reasoning, and estimation. First, we specify critical structures and procedures to establish direct relationships. Second, we examine dependence using two inference forms. Finally, we apply Boolean operations to explain counterfactual dependence, aligning theoretical logic and empirical evidence with resource dependence propositions and boundary formation.

The study identifies five principles for counterfactual dependence, as outlined by Durand and Vaara (2009). First, we ensure conceptual clarity by maintaining distinct and consistent sets within resource dependence research, defining interdependence as the antecedent and non-equity as the consequent to establish clear causal dependence. Second, cotenability is observed by logically linking the antecedent to its consequent, ensuring compatibility with direct relations. Third, we align antecedents and consequents with empirical facts about key actors, emphasising boundary interactions in counterfactual dependence. Fourth, we maintain theoretical consistency, ensuring that the relationship between interdependence and non-equity aligns with causal dependence. Fifth, we ensure generalisability by maintaining consistency in antecedent-consequent relations.

The findings demonstrates that causal (counterfactual) dependence enhances discussions on resource dependence in international business, particularly when interdependence influences non-equity relationships. This analysis builds on logical inferences about cause and effect within resource dependence, distinguishing between temporal and modal generalisations. Using Boolean operations, we examine temporal logic and relations shaped by restrictions, without requiring long-term commitments. By employing consensus operations, we present alternative combinations, revealing how consensus and dissensus lead to logical contradictions and transitions from causal to counterfactual dependence.

A distinguishing feature of this study emphasis on causal (counterfactual) dependence and its empirical methods based on statistical correlation. Our approach underscores the significance of large sample sizes for robust analysis, in contrast to small-sample methodologies which may introduce biases. However, we acknowledge that small samples can yield intriguing results in the early stages of research. By formally establishing propositions, we highlight conceptual divergences from existing research,

distinguishing between hypothesis measures and proposition concepts to enhance theoretical contributions.

Using case-study data from nine cases, researcher demonstrate direct relationships across various combinations, addressing differences in equivalence through direct relations and interactions. To minimise challenges associated with fuzzy logic, we focus on causation based on dependence. By explaining interactions as true or false, researcher develop provable, semantically accurate sets that capture the meaning of interactions. While potential dual effects may introduce fuzzy explanations, we mitigate this fuzziness by emphasising causation over general similarity (Charlton, 1983; Lewis, 1970).

To achieve precision without relying solely on statistical correlation, algebraic sets is used to represent counterfactual dependence, adopting a systematic research approach. This approach proves particularly effective in analysing restrictions, interdependence, and non-equity relations, offering insights into rethinking resource dependence and explaining boundary interactions.

CONTRIBUTION

This research contributes to resource dependence theory by highlighting the role of causal (counterfactual) dependence between interdependence and non-equity relations. The researcher specifically highlight how consensus on restrictions influences isomorphism, particularly when firms and resource holders differ significantly. In such cases, agreement on restrictions determines the pathway to achieving similarity. Consensus on restrictions also shapes reporting structures by establishing rules and limitations, ensuring operational consistency and effectiveness. This process is crucial for enhancing cooperation and integration within a shared institutional framework.

Furthermore, this study advances the understanding of international business strategy and institutional restrictions, offering valuable insights for policymakers. The interplay between counterfactual dependence, isomorphism and boundary dependence provides a crucial perspective for regulatory decision-making. By analysing potential outcomes of various regulatory and policy changes, policymakers can better anticipate their impact on resource interdependence, ensuring stable resource dependence. This understanding enables firms and resource holders to reconfigure operations to enhance efficiency and reduce costs. Moreover, policymakers can design and implement resource allocation strategies that minimise dependency risks and promote equitable access to essential resources, particularly in industries heavily reliant on external resources. This, in turn, fosters national economic growth.

The investigation also serves as a bridge between qualitative and quantitative methodologies, offering insights for both researchers and industry practitioners. By integrating fuzzy logic and Boolean set theory, the researcher clarify the equivalence of propositions through set substitutions. The combination of interview-based relations and set-theoretic logic yields provable responses, while algebraic logic helps establish causal dependence, contributing to a richer contextual exploration. Fuzzy (algebraic) logic supports inductive theory building, balancing contextual and explanatory rigor, especially in areas where evolving logic challenges boundary definitions. This approach enhances theoretical development, allowing for a clearer understanding of resource dependence, isomorphism and boundary interactions. By combining inductive theory building with algebraic operations, our study provides a robust framework for analysing resource dependence, isomorphism, and boundary interactions. This contribution offers both theoretical advancements and practical applications in the field.

LIMITATIONS

While this study makes important contributions, it is crucial to acknowledge certain limitations that may influence the fundamental relationships examined. Researcher do not claim to provide a comprehensive classification; rather, this approach is intended to explore distinctions within counterfactual dependence, boundary interactions and resource dependence. Firstly, it focus on intellectual property rights (IPRs) does not extend to firm-specific advantages (FSAs), which are tied to particular protected designation of origin (PDO) locations. While the findings hold value for policymakers, further research is required to explore territorial constraints and institutional requirements on a global scale. Second, the sample is drawn exclusively from a single country, which presents a significant limitation. A larger and more geographically diverse sample would enhance the generalisability of these findings. This raises the question of whether our study's outcome can be extrapolated to other PDO and IPR regions or applied to more complex IPRs cases within supranational institutions such as the European Union (EU). The regulatory heterogeneity between the EU and non-EU markets underscores the need for cross-country comparisons to validate the industry applicability of our approach. If the study's framework holds across diverse settings, it could contribute significantly to scholarly research and offer deeper insights into complex market interactions. Third, the study acknowledges the possibility of unobserved elements that were not considered in the analysis. Future researchers may expand on this finding by drawing parallels between causation and causal dependence, as exemplified by Charlton's (1983) theory of continuity in change. Charlton argues that the structures and procedures used to determine relationships typically lead to continuation rather than change. Furthermore, while certain factors may cause change, they do not consistently result in change nor does every change require a specific cause. This suggests the existence of other elements contributing to continuity and change simultaneously (Charlton, 1983, p. 152).

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