CORPORATE DIVERSIFICATION, ECONOMIES OF SCOPE, AND THE RISK-RETURN RELATIONSHIP

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Abstract

Corporate diversification was believed to enhance returns and reduce risk. Despite early speculations about the resulting favorable combination of high returns and low risk, empirical research was split between supporting and rejecting that idea. The lack of theory regarding the risk-return relationship in diversified firms and the empirical controversy made researchers conclude that the favorable risk-return performance is impossible and that search for it is futile and atheoretical. This study uses a formal model to develop the missing theory of the risk-return relationship in corporate diversification. The model involves two types of economies of scope, intra-temporal economies from resource sharing and inter-temporal economies from resource redeployment. The model demonstrates that, when both economies are present, firms sustain the predominantly negative risk-return relationship and can achieve the favorable combination of high returns and low risk. The model carefully explains mechanisms underlying these results.

Keywords: risk-return relationship, Bowman paradox, corporate diversification, economies of scope, resource redeployment, resource sharing, resource allocation.

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INTRODUCTION

A key reason for corporate diversification is that a diversified firm enhances returns by allocating resources across its multiple businesses. Such an improvement represents "economies of scope" (Panzar and Willig, 1981) that derive from the ability of a multi-business firm to use resources across its businesses more efficiently than single-business firms can do (Hill, Hitt, and Hoskisson, 1992). One type of economies of scope involves redeployment of resources from one business to another business within the firm. Because the firm needs to withdraw resources from a business where they were used in the past to start using them in another business in the next time, such economies were named "inter-temporal" (Helfat and Eisenhardt, 2004).[1] Another type of economies of scope is realized by a diversified firm when it shares technological knowledge across businesses, thus avoiding the costly duplication in the knowledge development (Bryce and Winter, 2009; Teece *et al*., 1994). By contrast with economies from redeployment, economies of scope from resource sharing were named "intra-temporal" (Helfat and Eisenhardt, 2004) because they occur when the same resources are used in a firm's multiple businesses at the same time.[2] "Relatedness," defined by Rumelt (1974) as the similarity of resource requirements between businesses, helps the firm redeploy and share resources across its businesses. Accordingly, the idea that economies of scope from allocating a firm's resources across related businesses enhance corporate returns was corroborated in formal models (Sakhartov and Folta, 2014; 2015) and empirical studies (Anand and Singh, 1997; Montgomery and Wernerfelt, 1988; Wu, 2013).

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[1] Laurent Beaudoin, the CEO of Bombardier Inc., counted on the improvement of returns by redeployment: "We were the leader in the snowmobile industry until the energy crisis. We were forced to look for something else to do and resolved to diversify into a business where we could put the skills we had developed. Instead of shutting down one of our facilities, we reorganized the snowmobile operation, concentrate it in one facility, and free up another to build subway cars." (Baghai *et al*., 1997: 4-7).

[2] Using the running example of Bombardier Inc., as Beaudoin explained, the firm enhanced returns by sharing its technological knowledge: "We are striving to facilitate the transfer of expertise across groups. We developed the Bombardier Manufacturing System and the Bombardier Engineering System to capture our basic principles of design and manufacturing... Our information officers share their experiences of systems and vendors… As a result, we are saving time and money." (Baghai *et al*., 1997: 29).

In addition to the added returns, researchers often expect a decrease of risk in diversified firms (Chen and Steiner, 2000; Comment and Jarrell, 1995; Kim, Kim, and Pantzalis, 2001), especially when such firms combine businesses with negatively correlated returns (Bettis and Hall 1982).[3]

Can corporate diversification simultaneously increase returns and decrease risk? If so, the knowledge of the conditions with which such diversification entails both benefits would be important to corporate strategy researchers and to corporate managers. This could also explain the 'risk/return paradox' (Bowman, 1980) with which a firm's returns are negatively associated with its risk, and which motivated voluminous research. Such a negative relation is paradoxical because the natural aversion to risk demands that higher risk of investment be rewarded with higher returns (Samuelson, 1951; Solomon and Pringle, 1980). This more intuitive positive relation was expected in corporate strategy: "The extent to which he [a corporate strategist] wishes to undertake low or high risk presumably depends on his profit objective. The higher he sets the latter, the more willing he must be to assume a correspondingly high risk..." (Andrews, 1971: 37). It was also corroborated by Bettis (1981) who found a statistically significant positive association between risk and returns in diversified firms; and by Amit and Livnat (1988a) whose empirical results showed that diversified firms clustered into those having (a) high risk and high returns, (b) medium risk and medium returns, or (c) low risk and low returns. Besides, Amit and Livnat (1988b) reported that diversified firms that had higher returns also had higher risk. However, contrary to the intuitive positive association between risk and returns, Bettis (1982) found that association to be negative, even if only weakly significant; Amit and Livnat (1989) detected that efficient diversifiers manage to reduce risk without reducing returns. Furthermore,

[3] Continuing with the example of Bombardier Inc., in addition to the appeal to improved returns, Beaudoin alluded to the reduction of risk that occurred when his firm diversified across businesses with countercyclical (*i.e.*, negatively correlated) returns: "We wanted something that that would be counter-cyclical to our existing product line and would react to an event like the energy crisis in a very different way from our main business, the snowmobile" (Baghai *et al*., 1997: 6).

predating Bowman (1980), Rumelt (1974: 94) expected the negative relationship between risk and returns in diversified firms: "[related diversification] strategies that are associated with high profitability tend also to be associated with... lower amounts of variability [*i.e.*, risk]," and confirmed that expectation empirically; that result was replicated by Christensen and Montgomery (1981). Finally, Bettis and Mahajan (1985) and Lubatkin and Rogers (1989) demonstrated that some diversified firms managed to achieve a combination of high returns and low risk; Montgomery and Singh (1984) showed that unrelated diversification strategy that entailed lower returns also entailed higher risk. Thus, corporate diversification research has been split between supporting the idea that diversification can both increase returns and decrease risk (Amit and Livnat, 1989; Bettis, 1982; Bettis and Mahajan, 1985; Christensen and Montgomery, 1981; Lubatkin and Rogers, 1989; Montgomery and Singh, 1984; Rumelt, 1974), and rejecting it (Amit and Livnat, 1988a; 1988b; Bettis, 1981).

As reviewed in Andersen, Denrell, and Bettis (2007) and Henkel (2009), three research streams could inform the query into whether corporate diversification can both raise returns and cut risk. The first stream allows for a negative relationship between risk and returns only as a statistical misspecification or spuriousness (Denrell, 2004; Henkel, 2000, 2009; Oviatt and Bauerschmidt, 1991; Ruefli, 1990; Wiseman and Bromiley, 1991). The second stream, agnostic about corporate diversification, is based on the prospect theory (Kahneman and Tversky, 1979) and the behavioral theory of the firm (Cyert and March, 1963) and explains that a negative association between risk and returns occurs because managers in firms whose returns are below a reference point (*i.e.*, low) take more risk to raise them. The third stream, unlike the first two, considers corporate diversification and empirically diagnoses the conditions, in terms of relatedness of a firm's businesses to each other, that support a negative association between risk and returns. For example, Bettis and Hall (1982) found that such a negative relationship holds when businesses in a diversified firm are related to each other. By contrast, Kim, Hwang, and Burgers (1993: 284) suggested that "a favorable risk-return performance is extremely hard to achieve with product diversification alone, be it related or unrelated"; whereas Chang and Thomas (1989: 283) concluded that "no clear theoretical rationale exists to expect either related or unrelated product diversification to lead to… a favorable risk-return profile." Indeed, as the review by Nickel and Rodriguez (2002: 11) summarized such attempts: "there was no causal relationship between diversification strategy and risk-return relationship. Product diversification seems to have little impact on the negative risk-return relation… or no at all."

Given the lack of empirical consensus regarding a negative risk-return relationship in corporate diversification and the absence of a theoretical explanation for when diversification entails high returns and low risk, this study builds a formal model. According to Adner *et al.* (2009) and Hannah, Tidhar, and Eisenhardt (2018), formalism provides precision and logical consistency. In this study, precision derives from the use of the established operationalization of economies of scope. Namely, relatedness was raised as a key determinant of such economies (Helfat and Eisenhardt, 2004; Montgomery and Wernerrfelt, 1988; Sakhartov and Folta, 2014) and as a possible moderator of the risk-return relationship (Bettis and Hall, 1982; Chang and Thomas, 1989; Kim *et al.*, 1993). Another pertinent variable raised in research (Bettis and Hall, 1982; Chang and Thomas, 1989) is the correlation of returns between a firm's businesses. Accordingly, relatedness and correlation are both involved in the model. In turn, the logical consistency is ensured by modeling the use of the inherently dynamic economies from resource redeployment based on the principle of dynamic optimality (Bellman, 1957). This approach is established in research (Kogut and Kulatilaka, 1994; Sakhartov and Folta, 2014; 2015; Triantis and Hodder, 1990). Such formalism was shown to avoid substantial decision biases in using economies of scope (Sakhartov and Folta, 2014); it also overcomes the limitations of verbal theorizing on the complex inter-temporal phenomenon (Ghemawat and Cassiman, 2007: 530).

Responding to the requirement for a formal model to contribute "unanticipated implications" (Adner *et al*., 2009: 202), the model counters the skepticism about the existence of a negative relationship between risk and returns (Chang and Thomas, 1989; Denrell, 2004; Henkel, 2000, 2009; Nickel and Rodriguez, 2002; Oviatt and Bauerschmidt, 1991; Ruefli, 1990; Wiseman and Bromiley, 1991) and derives it in corporate diversification.[4] Notably, if both types of economies of scope are present, the negative relationship between risk and returns holds when either (a) return correlation is not strongly positive, *or* (b) relatedness is not weak. The existence of that apparently paradoxically relationship is theoretically shown to be systematic rather than accidental—it is explained based on how relatedness and return correlation affect risk and returns. Furthermore, the relationship is found to hold under conditions that were not even speculated to generate it. In particular, the detected negative relationship between risk and returns exist not only among relatedly diversified firms (*i.e*., item "b" above) but also among unrelatedly diversified firms (*i.e*., item "a" above). An additional justification for the use of the formal model is that those extended conditions for the negative risk-return relationship emerge from the complex interplay between the two types of economies of scope. This extension is absent when one type of such economies or their interplay with each other is ignored.

Finally, echoing the idea that "analytic models often address why (causal mechanisms) or when (boundary conditions) [some] patterns occur" (Hannah *et al*., 2018: 6), the model

[4] Research in finance (*e.g*., Comment and Jarrell, 1995) advanced two theoretical explanations for the negative risk-return relationship in diversified firms. Thus, firms whose businesses have imperfectly correlated returns have lower risk (Lewellen, 1971), which reduces the cost of borrowing and increases net returns. Also, the reduction of risk by corporate diversification entails the reduction of agency costs (Stulz, 1990), thus increasing returns. This study keeps agnostic with regard to those financial explanations and focuses, instead, on the strategic implications of economies of scope.

identifies (*i.e.*, "when") and explains (*i.e.*, "why") the specific conditions with which corporate diversification entails both high returns and low risk. In particular, if both types of economies of scope are present, a diversified firm enjoys a combination of the highest returns and of the lowest risk when (a) the firm diversifies across closely related businesses, *and* (b) returns in those businesses are strongly negatively correlated with each other. If the latter condition is not met, high returns in the diversified firm can still be combined with relatively low levels of corporate risk unless return correlation is strongly positive. The conditions for the negative risk-return relationship and for the combination of high returns with low risk in diversified firms that are derived below lay the groundwork for better empirical tests and facilitate better decision making by corporate managers.

MODEL

The model considers a diversified firm that, at the initial time $t = 0$, deploys proportion $m_{i0} = 0.5$ of resources in business i and proportion $(1 - m_{i0}) = 0.5$ in business j. The resources have a finite life that ends at the terminal time $t = T$. Two types of economies of scope, intra-temporal from resource sharing and inter-temporal from resource redeployment, are available to the firm, thus capturing the key motivation for corporate diversification. The model involves the following three parts: (a) a specification of margins in the two businesses, (b) a specification of economies of scope, and (c) estimations of corporate risk and of corporate returns.

Margins in the firm's businesses

Following previous models of economies of scope in corporate diversification, margins in the firm's businesses are made exogenous and uncertain. Namely, like in Sakhartov and Folta (2014; 2015), margins C_{it} and C_{jt} in businesses i and j follow the geometric Brownian process:

$$C_{it} = C_{i0} e^{\left[\left(\mu_i - \frac{\sigma_i^2}{2}\right) t + \sigma_i W_{it}\right]} \quad (1)$$

$$C_{jt} = C_{j0} e^{\left[\left(\mu_j - \frac{\sigma_j^2}{2}\right) t + \sigma_j W_{jt}\right]} \quad (2)$$

$$dW_{it} dW_{jt} = \rho\, dt\,. \quad (3)$$

Here, C_{i0} and C_{j0} are margins in businesses i and j at the initial time $t = 0$; μ_i and μ_j are drifts for the margins; σ_i and σ_j are volatilities of these margins; and W_{it} and W_{jt} are Brownian motions with the correlation coefficient ρ. In this specification, correlation ρ inversely captures the degree to which the margins in the firm's businesses are countercyclical.

Economies of scope

The specification of economies of scope replicates their formalizations in Sakhartov (2017) and Sakhartov and Folta (2014; 2015). The firm receives intra-temporal economies of scope at time t if it stays in both businesses at that time, thus contemporaneously sharing resources between them. In this case, the firm realizes the following current net cash flow:

$$F_t = \left[1 + \mathbf{1}_{0<m_{it}<1}\left(\beta - 1\right)\right]\left[m_{it} C_{it} + \left(1 - m_{it}\right) C_{jt}\right]. \quad (4)$$

In Equation 4, β is the sharing factor that is a direct manifestation of relatedness between businesses i and j altering the return to the use of a unit of the firm's resources in the firm's businesses. When $\beta < 1$, businesses i and j are only weakly related and diversification reduces corporate returns. This possibility was included in previous modeling (Sakhartov, 2017) because, while relatedness raises the cross-applicability of knowledge, not any extent of relatedness enhances corporate returns. Because knowledge sharing is costly (Maritan and Brush, 2003), in unrelated diversification the costs of such sharing can exceed small cost savings. Conversely, when $\beta > 1$, i and j are strongly related and diversification increases corporate returns. The reduction or the enhancement of corporate returns is present automatically when the firm shares resources: expression $\mathbf{1}_{0<m_{it}<1}$ equals one when $0 < m_{it} < 1$ and is zero otherwise.[5]

The firm realizes inter-temporal economies of scope by withdrawing some resources that it used in business i (or j) in the immediate previous time $(t-\partial t)$ and redeploying these resources to business j (or i). With such economies of scope, the current net cash flow realized by the firm at time t is as follows:

$$F_t = m_{it}C_{it} + (1-m_{it})C_{jt} - S\left[\max\left(0, m_{it} - m_{it-\partial t}\right)C_{it} + \max\left(0, m_{it-\partial t} - m_{it}\right)C_{jt}\right]. \quad (5)$$

In Equation 5, the term $m_{it}C_{it} + (1-m_{it})C_{jt}$ captures the current net cash flow that the firm earns if it does not use redeployment in the current period: the firm deployed proportion m_{it} of its resources in business i and proportion $(1-m_{it})$ in business j in the immediate previous period $(t-\partial t)$, and the firm continues to use proportion m_{it} of resources in business i and proportion $(1-m_{it})$ in business j in the current period t. If the firm redeploys resources, the term $S\left[\max\left(0, m_{it} - m_{it-\partial t}\right)C_{it} + \max\left(0, m_{it-\partial t} - m_{it}\right)C_{jt}\right]$ in Equation 5 can become greater than zero and it captures the total redeployment cost that the firm incurs in redeploying proportion $m_{it} - m_{it-\partial t}$ to business i or proportion $m_{it-\partial t} - m_{it}$ to business j. The model assumes that such a cost represents the loss in efficiency of deploying resources in the new use relative to their continued deployment in that use; the loss is mitigated by relatedness (Montgomery and

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[5] In addition to enhancing corporate returns, the sharing factor β (directly representing relatedness) increases corporate risk. Thus, variance of the net cash flow that a diversified firm generates at time t in the presence of synergy can be expressed as

$$\mathrm{Var}\left[F_t\right] = \left[1 + \mathbf{1}_{0<m_{it}<1}\left(\beta - 1\right)\right]^2 \left[m_{i0}^2 C_{i0}^2 e^{2\mu_i t}(e^{\sigma_i^2 t} - 1) + (1-m_{i0})^2 C_{j0}^2 e^{2\mu_j t}(e^{\sigma_j^2 t} - 1) + 2m_{i0}(1-m_{i0})C_{i0}C_{j0}e^{(\mu_i+\mu_j)t}(e^{\rho\sigma_i\sigma_j t} - 1)\right].$$

According to this statement, variance of the net cash flow of the diversified firm monotonically increases in the sharing factor β.

Wernerfelt, 1988). Because the model captures efficiency with margins C_{it} and C_{jt}, the total cost of redeploying resources is a product of the margin in the recipient business, of the marginal redeployment cost, $S \geq 0$; and of the amount of redeployed resources. When both types of economies of scope are present, the firm's current net cash flow is as follows:

$$\begin{aligned} F_t &= \left[1 + \mathbf{1}_{0<m_{it}<1}\left(\beta - 1\right)\right]\left(m_{it}C_{it} + (1-m_{it})C_{jt}\right) \\ &-S\left[\max\left(0, m_{it} - m_{it-\partial t}\right)C_{it} + \max\left(0, m_{it-\partial t} - m_{it}\right)C_{jt}\right] \end{aligned}.[6] \quad (6)$$

Estimations of corporate risk and of corporate returns

This study uses the variance-based measure of risk that is common in research on the risk-return relationship. Namely, risk is estimated as the variance for the discounted net present value V_0 of cash flows that will be accumulated by the diversified firm over the useful life of its resources:

$$Risk = \mathrm{Var}\left[V_0\right]. \quad (7)$$

In turn, corporate returns are assessed as the expectation for the discounted net present value V_0:

$$Returns = \mathrm{E}\left[V_0\right], \quad (8)$$

where r is the risk-free interest rate used for temporal discounting.

The discounted net present value V_0, as well as the ensuing *Risk* and *Returns*, cannot be derived analytically in the longitudinal setting specified with Equations 1–3. This happens because the current resource deployment choice m_{it} is selected in each period endogenously.

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[6] Because S is reduced by relatedness and β is enhanced by relatedness, an assumption about a strong negative relationship between S and β appears reasonable. There has been no research that validated that assumption. To the contrary, Sakhartov (2017) showed that the relationship between the two manifestations of relatedness is weak. Therefore, just like Sakhartov and Folta (2014) and Sakhartov (2017), this study avoids assuming the unestablished relationship. Also, return correlation between a firm's businesses was sometimes assumed redundant to relatedness of such businesses to each other. For example, both Bettis and Hall (1982: 257) and Lubatkin and Chatterjee (1994: 130) assumed that unrelated businesses should have negatively correlated returns. There has been practically no research that validated that assumption, except for the analysis in Sakhartov and Folta (2015) that demonstrated that there is no significant relationship between relatedness and return correlation. Therefore, just like Sakhartov and Folta (2015), this study avoids assuming the tenuous relationship.

This endogenous resource deployment choice m_{it} depends on the previous choice $m_{it-\partial t}$. Furthermore, the current resource deployment choice m_{it} affects not only the current net cash flow F_t but also the discounted net present value $V_{t+\partial t}$ as seen at the immediate next time $t+\partial t$. This path-dependence in resource deployment choices by the diversified firm is accommodated with the Bellman equation (Bellman 1957) that imposes the dynamic optimality of such choices:

$$\left(m_{it}^{*}\middle|m_{it-\partial t}\right)=\arg\max_{m_{it}}\left\{F_t + e^{-r\partial t}\mathrm{E}\left[V_{t+\partial t} \mid m_{it}^{*}\right]\right\}. \qquad (9)$$

This equation can be restated for the discounted net present value V_t of cash flows that will be accumulated by the firm from the considered time t to the terminal time T:

$$V_t=\max_{m_{it}}\left\{F_t + e^{-r\partial t}\mathrm{E}\left[V_{t+\partial t} \mid m_{it}^{*}\right]\right\}. \qquad (10)$$

In Equations 9 and 10, $V_{t+\partial t}$ is the discounted net present value as seen at time $t+\partial t$ and as expected to be accumulated between the immediate next time $t+\partial t$ and the end of the useful life of the firm's resources $t=T$, conditioned on the current choice m_{it}^{*}.

Equations 9 and 10 split the analytically intractable estimation into a sequence of simpler problems solved with backward induction. The solution involves discretization of the distribution for C_{it} and C_{jt}. The model follows the established approach of Cox, Ross, and Rubinstein (1979) and Boyle, Evnine, and Gibbs (1989) to discretize Equations 1–3 with a binomial lattice. On the lattice, the next-period margins $C_{it+\partial t}$ and $C_{jt+\partial t}$ have four states: $C_{it+\partial t}^{u}$ and $C_{jt+\partial t}^{u}$ with probability q^{uu}; $C_{it+\partial t}^{u}$ and $C_{jt+\partial t}^{d}$ with probability q^{ud}; $C_{it+\partial t}^{d}$ and $C_{jt+\partial t}^{u}$ with probability q^{du}; or $C_{it+\partial t}^{d}$ and $C_{jt+\partial t}^{d}$ with probability q^{dd}.[7] Thus, $\mathrm{E}\left[V_{t+\partial t}\right]=q^{uu}V_{t+\partial t}^{uu}+q^{ud}V_{t+\partial t}^{ud}+q^{du}V_{t+\partial t}^{du}+q^{dd}V_{t+\partial t}^{dd}$

[7] The formulas for calculating $C_{it+\partial t}^{u}$, $C_{jt+\partial t}^{u}$, $C_{it+\partial t}^{d}$, $C_{jt+\partial t}^{d}$, q^{uu}, q^{ud}, q^{du}, q^{dd} are available in Sakhartov and Folta (2015).

where $V_{t+\partial t}^{uu}$ is calculated using $C_{it+\partial t}^{u}$ and $C_{jt+\partial t}^{u}$; $V_{t+\partial t}^{ud}$ is estimated using $C_{it+\partial t}^{u}$ and $C_{jt+\partial t}^{d}$; $V_{t+\partial t}^{du}$, is assessed using $C_{it+\partial t}^{d}$ and $C_{jt+\partial t}^{u}$; and $V_{t+\partial t}^{dd}$ is computed using $C_{it+\partial t}^{d}$ and $C_{jt+\partial t}^{d}$.

The backward induction starts at time $t = T - \partial t$ with the terminal condition $V_T = 0$ (*i.e.*, the firm's resources fully depreciate by time $t = T$). The use of Equations 9 and 10 proceeds recursively backward in time with a step $\partial t = T / N$ (where N is the number of time-discretization steps) until the procedure reaches time $t = 0$. In each step and for each possible realization of the margins, the equations return the discounted net present value V_t and the optimal use of the firm's resources $\left(m_{it}^{*} \middle| m_{it-\partial t}\right)$ that is conditioned on their previous use. Although the backward induction retrieves the choices $\left(m_{it}^{*} \middle| m_{it-\partial t}\right)$ at each possible realization of the margins and over the whole lifecycle of the resources, the resulting number of possible realizations for the random variable of the discounted net present value V_0 (*i.e.*, the number of paths through which the margins can evolve) on the lattice with N steps is 4^N. With $N = 100$, this number is 4^{100}=$1.6069*10^{60}$. The estimation of the variance and of the mean for V_0 using the whole population of such realizations is obviously impossible. Meanwhile, the following Monte-Carlo simulation is used to sample V_0 and then to estimate its variance and mean based on that sample.

Using transitional probabilities q^{uu}, q^{ud}, q^{du}, and q^{dd}, one million paths are simulated for margins C_{it} and C_{jt} over time $t \in [0, T]$. The use of the transition probabilities for simulating the sample of paths preserves the properties of the probability distribution for C_{it} and C_{jt} specified with Equations 1–3, including correlation ρ. Because the firm is initially diversified (*i.e.*, $m_{i0} = 0.5$), starting with the initial time $t = 0$ and using the derived optimal conditional use of resources $\left(m_{it}^{*}\middle|m_{it-\partial t}\right)$, the net cash flow is estimated in each increment of a path based on Equation 8 going recursively forward in time on that path. With this approach, each of the 1,000,000 sampled realizations V_0^x for the discounted net present value V_0 can be expressed as follows (the superscript x indexes paths and thus realizations of F_t and of V_0):

$$V_0^x = \sum_{t=0}^{t=T} e^{-rt} F_t^x \,. \qquad (11)$$

RESULTS

The model seeks to identify how the chief explanation for corporate diversification, economies of scope, affects the possibility that such diversification leads to a favorable combination of high corporate returns and low corporate risk. In addition, the model examines whether a systematic negative risk-return relationship can be attributed to corporate diversification, thus explaining the risk-return paradox. Following previous attempts to address these issues based on relatedness of a firm's businesses to each other and based on correlation of returns between them, the model is applied to various combinations of these variables. If the variation of a parameter is not involved in a particular result, the following values are used by default: $\beta = 1$, $S = 28$, $C_{i0} = C_{j0} = 0.08$, $\sigma_i = \sigma_j = 1$, $T = 1$, $N = 100$, and $r = 0.08$. If the variation of a parameter is needed for the result, the range for the parameter is provided with the respective figure. The results are grouped in three subsections. The first subsection disallows inter-temporal economies of scope from resource redeployment and focuses on intra-temporal economies of scope from resource sharing. The second subsection disallows intra-temporal economies from resource sharing and focuses on inter-temporal economies from resource redeployment. The third subsection considers the context where both types of economies of scope are present.

Intra-temporal economies of scope from resource sharing and the risk-return relationship

This subsection analyzes the relationship between risk and returns in the diversified firm when only intra-temporal economies of scope from resource sharing are present. The red line in Figure 1 shows a connected scatterplot of *Risk* against *Returns* for combinations of the sharing factor in the range of $\beta \in [0.69, 1.31]$ and of return correlation in the range of $\rho \in [-0.9, 0.9]$. To remind, the sharing factor in this analysis directly represents relatedness between businesses i and j. A linear trendline summarizes the relationship between risk and returns. A quadratic trendline checks whether this relationship can turn negative at least in some increments.

Insert Figure 1 here

The linear trendline in Figure 1 has an upward slope. This means that, in diversified firms applying economies of scope from resource sharing, risk is positively associated with returns. The slope of the blue line also suggests that, if all analyzed combinations of β and ρ represented equally likely empirical observations that were used to run an ordinary least-square regression of risk on returns, that model would support the conventional positive risk-return relationship. Even when the curvilinearity of that relationship is enabled in the green line, the relationship remains robustly positive. Accordingly, the two trendlines support the conventional view and reveal no evidence of the risk-return paradox. Despite this generally positive association between risk and returns, Figure 1 contains datapoints located in its bottom right part where returns are the highest and risk is relatively low. This becomes possible because Figure 1 contains vertical lines regularly placed around the trendlines and the vertical line that coincides with the right margin where returns are the highest goes down to a relatively low level of risk. However, that vertical line never gets down to the bottom of Figure 1 where risk is the lowest. These patterns in Figure 1 are addressed in Figure 2.

Insert Figure 2 here

Panel A in Figure 2 demonstrates how corporate risk derives from the sharing factor and from return correlation. The change of the color from dark blue in the bottom left corner to red in the top right corner indicates that, with economies of scope from resource sharing, risk in the diversified firm monotonically increases both in the sharing factor and in return correlation. The two effects have the following formal justification. Variance of the net cash flow that the firm generates at time t can be expressed as $\mathrm{Var}\left[F_t\right]=\left[1+\mathbf{1}_{0<m_{it}<1}\left(\beta-1\right)\right]^2\left[m_{i0}^2 C_{i0}^2 e^{2\mu_i t}(e^{\sigma_i^2 t}-1)+(1-m_{i0})^2 C_{j0}^2 e^{2\mu_j t}(e^{\sigma_j^2 t}-1)+2m_{i0}(1-m_{i0})C_{i0}C_{j0}e^{(\mu_i+\mu_j)t}(e^{\rho\sigma_i\sigma_j t}-1)\right]$. This statement shows that the variance of the net cash flow at time t monotonically increases both in the sharing factor β and in return correlation ρ, aggregating into the positive effects of both parameters on *Risk*. In turn, Panel B shows how corporate returns derive from the sharing factor and from return correlation. The change of the color from dark blue at the left margin to red at the right margin, throughout the whole panel, reveals that returns in the diversified firm monotonically increase in the sharing factor. This effect, previously demonstrated in Sakhartov and Folta (2014), follows directly from the positive impact of β on the net cash flow that the firm generates at time t (*i.e.*, Equation 4) and aggregates into the monotonic positive effect of β on *Returns*. The lack of the change of color in the vertical dimension in Panel B indicates that, with economies of scope from resource sharing, corporate returns do not depend on return correlation. This happens because the net cash flow that the firm generates at time t is estimated as expectation that complies with the general property of linearity of expectation of the sum of any random variables X and Y such that $\mathrm{E}\left[X+Y\right]=\mathrm{E}\left[X\right]+\mathrm{E}\left[Y\right]$ and is thus is independent of ρ.

The fact that the sharing factor increases both risk and returns in Figure 2 supports the robust positive association between risk and returns in Figure 1. In turn, the difference in the effect of return correlation between risk (*i.e.*, monotonic positive effect) and returns (*i.e.*, no effect) creates an interesting pattern wherein the same level of returns in each vertical stripe of the same color in Panel B is accompanied with a wide variety of values of risk in Panel A. This observation explains the regular vertical lines in Figure 1. Despite this possibility to observe various levels of risk with the same level of returns, the positive effect of the sharing factor on risk sets the boundaries for such variation: the higher the sharing factor, the higher is the lowest risk that can be observed with strong negative correlation and the higher is the highest risk that can be observed with strong positive correlation. The latter claims are substantiated with the upward trends in both the lower ends and the upper eds of the vertical red lines in the direction from the left margin to the right margin in Figure 1. In the context of the feasibility of the very favorable combination of the highest returns with the lowest risk, the upward trend in the minimal possible risk in the direction of higher returns completely disallows this possibility.

To sum up the analysis of the implications of intra-temporal economies of scope from resource sharing on the risk-return relationship, the insights revealed in Figures 1 and 2 can be summarized as follows: (a) corporate risk is positively associated with corporate returns; and (b) the highest corporate returns can never be accompanied with the lowest corporate risk.

Inter-temporal economies of scope from resource redeployment and the risk-return relationship

This subsection examines the relationship between risk and returns in diversified firms when only inter-temporal economies of scope from resource redeployment are present. The red line in Figure 3 depicts a connected scatterplot of *Risk* against *Returns* for combinations of the marginal redeployment cost in the range of $S \in [0, 75]$ and of return correlation in the range of $\rho \in [-0.9, 0.9]$. Redeployment cost S in this analysis inversely captures relatedness between i and j. A blue trendline continues to summarize the linear relationship between risk and returns. A green trendline tests whether this relationship can ever turn negative.

Insert Figure 3 here

The linear trendline in Figure 3 has an upward slope. Therefore, if all analyzed combinations of S and ρ represented equally likely empirical observations that were used to regress risk on returns, that regression would corroborate the conventional positive risk-return relationship. However, the quadratic trendline in Figure 3 contains an increment in the right half of the plot where the slope is negative. Accordingly, the combinations of return correlation and of the marginal redeployment cost that lead to moderate-to-high returns entail a negative risk-return relationship, thus rejecting the conventional view and supporting the risk-return paradox. However, even this negative relationship does not let high returns be accompanied by low risk at the right margin of the figure. Figure 4 is used to explain these results.

Insert Figure 4 here

Panel A in Figure 4 demonstrates how corporate risk bears upon the redeployment cost and return correlation. This figure resembles Panel D in Figure 3 in Sakhartov (2020) that (like this subsection) considered inter-temporal economies of scope from resources redeployment but (unlike this subsection) did not explore the risk-return relationship. The landscape in the panel is quite complex. Several observations summarize the essential patterns in this panel. First, except for the bottom left corner (*i.e.*, trivial redeployment costs combined with strong negative correlation), risk monotonically declines in redeployment costs. This prevailing negative effect holds because lower redeployment costs enhance the odds that the firm will redeploy resources over their lifecycle, which in turn raises the variance of returns; conversely, higher costs suppress redeployment and do not let risk grow (Sakhartov, 2020). The exception to this dominant pattern in the bottom left corner of Panel A derives from dependence of the optimal timing of resource redeployment on correlation and on the redeployment cost. As explained in Sakhartov (2020), with more-negative correlation and low redeployment costs, redeployment of resources to a currently outperforming business occurs earlier. Such earlier redeployment, before the range of future scenarios expands too broad, entails lower variation of returns. Second, with high redeployment costs (*i.e.*, to the right of the yellow area in Panel A), risk monotonically increases in correlation. This happens because, as described above, higher redeployment costs suppress the use of redeployment and make the dependence of risk on correlation resemble the relationship between risk and correlation in Panel A in Figure 2 at the level of the sharing factor of $\beta = 1$. Third, with low redeployment costs (*i.e.*, to the left of the yellow area in Panel A), the relationship between risk and correlation turns into inverse U-shaped, such that the highest values of risk correspond to the weakly-positive correlation. This relationship holds because correlation has two countervailing effects on risk. On the one hand, correlation reduces the efficiency of pooling risks of two streams of correlated returns, thus increasing risk. On the other hand, strong positive correlation makes returns in two businesses converge to each other, thus eliminating inducements for resource redeployment (Sakhartov and Folta, 2015) and mitigating the risk that would otherwise go up with redeployment (Sakhartov, 2020).

Panel B in Figure 4 illustrates how corporate returns derive from redeployment costs and return correlation. The change of the color from red to dark blue in the direction from south-west to north-east shows that returns monotonically decline both in redeployment costs and in return correlation. This happens because more-positive correlation and higher costs of redeployment lead to the lower value of the redeployment option (Sakhartov and Folta, 2015).

Figure 4 also maps the negative risk-return relationship observed in part of Figure 3 on redeployment costs and return correlation. In both panels, the broken white lines separate combinations of low redeployment costs and less than strong positively correlation that lead to the negative relationship from other combinations that support the positive relationship. The negative relationship can be explained by studying when, holding one of the two parameters constant, another has opposite signs for its effects on risk and on returns. Namely, when costs of redeployment are low, risk declines in the direction from moderately positive correlation to strong negative correlation, whereas returns grow in that direction. These oppositely directed effects lead to the negative part in the risk-return relationship (*i.e.*, the blue increment) in Panel C of Figure 5 where $S = 0$. Alternatively, when correlation is kept negative, risk declines in the direction from moderate redeployment costs to zero redeployment costs, while returns grow in that direction. These oppositely directed effects result in the negative increment in the risk-return relationship (i.e., the blue increment) in Panel A of Figure 6 where $\rho = -0.9$. A fact that will be useful for the comparison with the analysis in the next subsection is that none of the six plots in Figures 5 and 6 contains a monotonic negative relationship between risk and returns, thus corresponding to the limited size of the respective areas in Figure 4. Finally, the bottom left corner in Panel B of Figure 4 where returns are the highest and the respective corner of Panel A of Figure 4 where risk is relatively high both map on the right end of the red line in Figure 3 and prove the infeasibility of the favorable combinations of high returns with low risk. This happens because the use of redeployment with zero redeployment cost not only maximizes returns but also raises risk well above the level faced without redeployment (Sakhartov, 2020).

Insert Figures 5 and 6 here

To conclude the analysis of the implications of intra-temporal economies of scope from resource redeployment on the risk-return relationship, the insights revealed in Figures 3-6 can be summarized as follows: (a) corporate risk can be negatively associated with corporate returns only when redeployment costs are low and returns in the firm's businesses are not strongly positively correlated; and (b) no combinations of the redeployment costs (*i.e.*, relatedness) and of return correlation lead to the cooccurrence of high corporate returns and of low corporate risk.

Both types of economies of scope and the risk-return relationship

This subsection examines the relationship between risk and returns in the setting that is most inclusive of the benefits of corporate diversification: intra-temporal economies from resource sharing and inter-temporal economies from resource redeployment are both available to the firm. To make the analysis conservative regarding the possibility of the negative risk-return relationship, an intermediate value of $S = 28$ is used for the marginal redeployment cost rather than the lowest value of $S = 0$, which the previous subsection has demonstrated to support that relationship. The red line in Figure 7 plots risk against returns for combinations of the sharing $\beta \in [0.69, 1.31]$ and of return correlation $\rho \in [-0.9, 0.9]$. A blue line depicts the linear relationship between risk and returns, whereas a green trendline tests its possible curvilinearity.

Insert Figure 7 here

The fact that the blue line in Figure 7 has an upward slope suggests that, if all considered combinations of β and ρ represented equally likely empirical observations that were used to regress risk on returns, that regression would diagnose the paradoxical negative risk-return relationship. In turn, the green line also contains a vast part with a negative slope that complements the upward-sloped increment. Notably, the combinations of the sharing factor and of return correlation that lead to moderate or high returns also result in a negative risk-return relationship, thus rejecting the conventional view and supporting the risk-return paradox. Furthermore, Figure 7 contains datapoints situated right in the bottom right corner where returns are the highest and risk is the lowest. Thus, corporate diversification, when based on both types of economies of scope, can lead to the most favorable performance along the two measures of such diversification. These results are explained using Figure 8 below.

Insert Figure 8 here

Panel A in Figure 8 displays how risk depends on the sharing factor and on return correlation. Several patterns in the complex landscape of the panel are noteworthy. First, except for the top of the panel (*i.e.*, except for strong positive correlation), risk monotonically declines in the sharing factor. This prevailing negative effect contrasts with the robust positive effect of the sharing factor on risk diagnosed in Panel A of Figure 2. The reversal of this effect between Figures 2 and 8 conveys that the negative effect in Figure 8 is not intrinsic to resource sharing and, instead, emerges due to redeployment. The reversal takes place because high values of the sharing factor encourage resource sharing, thus discouraging redeployment (Sakhartov, 2017; Sakhartov and Folta, 2014). This suppression of redeployment by the sharing factor does not let redeployment increase risk (Sakhartov, 2020). Accordingly, the most inclusive setting with both types of economies of scope unveils the indirect negative effect of the sharing factor (*i.e.*, of relatedness) on risk that dominates its intrinsic positive effect. Second, this ultimately negative effect gets stronger closer to the bottom margin of Panel A where strong negative correlation acts as a powerful inducement for resource redeployment (Sakhartov and Folta, 2015) and where the suppression of redeployment by the sharing factor is very consequential. Conversely, at the top margin of Panel A, strong positive correlation makes returns in the two businesses converge to each other and acts a very weak inducement for redeployment, thus not letting the indirect negative effect of the sharing factor steadily dominate its intrinsic positive effect. Notably, the relationship between risk and the sharing factor turns into predominantly positive at the top margin of Panel A in Figure 8, in line with the natural positive effect of the sharing factor in the absence of redeployment in Panel A in Figure 2. Third, with high values of the sharing factor at the right margin of Panel A, risk increases in correlation. This effect replicates the effect of return correlation on risk in the absence of resource redeployment in Panel A in Figure 2 because high values of the sharing factor discourage such redeployment. Finally, when the sharing factor is low-to-medium, return correlation reduces risk with some tendency for an inverse U-shaped relationship. This pattern corresponds to the effect of return correlation on risk in the absence of economies of scope from resource sharing in Panel A in Figure 4 because below-average values of the sharing factor discourage resource sharing.

Panel B in Figure 8 illustrates how corporate returns derive from the sharing factor and return correlation. The change of the color from dark blue to red in the direction from north-west to south-east shows that returns monotonically decline in return correlation and grow in the sharing factor. The latter effect stems from the positive impact of β on the firm's net cash flow at time t (*i.e.*, Equation 4 and Panel B in Figure 2). The former effect takes place because less-positive correlation adds asymmetry in returns between the businesses which induces profitable redeployment (Sakhartov and Folta, 2015).

Figure 8 also maps the negative risk-return relationship observed in part of Figure 7 on the sharing factor and on correlation. In Figure 8, the broken white lines isolate combinations of the low-to-moderate sharing factor with positive correlation that lead to the often-expected positive relationship from other combinations that support the paradoxical relationship. In contrast to Figure 4 that contained only a small area with the negative risk-return relationship, the respective area dominates Figure 8. The sign of this relationship can be better understood by examining when, keeping one of the two parameters constant, another does not have the codirected effects on risk and on returns. To remind, the effects of the sharing factor on risk and returns were intrinsically co-directed (*i.e.*, both positive) in Figure 2. However, as described in the discussion of the patterns in Figure 8 above, when correlation is not strongly positive, risk declines in the sharing factor, whereas returns grow in the sharing factor. These oppositely-directed effects bring up the robust negative relationship between risk and returns illustrated in Panels A and B of Figure 10 where $\rho = -0.9$ and $\rho = 0$, respectively. Conversely, when return correlation is strongly positive, inducements for redeployment are weak and the sharing factor assumes its natural positive effect that is codirected with its effect on returns. These codirected effects lead to the predominantly positive increment in the risk-return relationship (*i.e.*, the vast red increment) in Panel C of Figure 10 where $\rho = 0.9$. In turn, in Figure 2, correlation naturally increased risk but had no impact on returns. Nevertheless, as described above in presenting the results in Panel A of Figure 8, correlation has a complex effect on risk: when the sharing factor is low-to-medium, return correlation reduces risk with some tendency for an inverse U-shaped relationship; while when the sharing factor is above average, risk increases in correlation. Thus, if both types of economies of scope are present and the sharing factor is above average, the effects of return correlation on risk and returns have opposite signs. This situation entails the robust negative relationship between risk and returns in Panel C of Figure 9 where $\beta = 1.31$.

Insert Figures 9 and 10 here

Ultimately, this most inclusive analysis of the implications of economies of scope on the risk-return relationship brings up the following key results in this study: (a) a diversified firm can enjoy a combination of the highest returns with the lowest risk when it diversifies across closely related businesses whose returns are also strongly negatively correlated with each other; and (b) the relationship between risk and returns is predominantly negative, except for when positive return correlation is combined with weak relatedness between the firm's businesses.

DISCUSSION

Economies of scope let a diversified firm enhance returns by allocating resources across multiple businesses, thus representing a key reason for corporate diversification. In addition to enhancing returns, corporate diversification based on such economies was often expected to decrease risk. Can diversified firms indeed simultaneously excel along these two critical measures of corporate performance? Despite the early speculations that such a favorable state can be achieved by firms diversifying across related businesses (Rumelt, 1974), voluminous empirical research has been split between supporting the idea that corporate diversification can both increase returns and decrease risk (Amit and Livnat, 1989; Bettis, 1982; Bettis and Mahajan, 1985; Christensen and Montgomery, 1981; Lubatkin and Rogers, 1989; Montgomery and Singh, 1984; Rumelt, 1974), and rejecting it (Amit and Livnat, 1988a; 1988b; Bettis, 1981). Based on the lack of theory regarding the relationship between risk and returns in diversified firms and based on the lack of consistency in the empirical results, researchers eventually concluded that a favorable risk-return performance is impossible to achieve with corporate diversification and that such expectations had been futile and atheoretical (Chang and Thomas, 1989; Nickel and Rodriguez, 2002).

Facing the state where the long-standing dilemma has not been resolved, this study appeals to the guidance of Makadok, Burton, and Barney (2018) on how to make theory contributions in strategic management. According to that guidance, causal mechanisms that underlie a theory's predictions represent its most central aspect; and a theoretical contribution can be made by comparing and contrasting various mechanisms, as well as by synthesizing them to detect their interplays. In the context of the considered dilemma, alternative mechanisms are indeed present because economies of scope involve two very different types: inter-temporal economies from resource redeployment and intra-temporal economies from resource sharing (Helfat and Eisenhardt, 2004). Furthermore, the two types were shown to interfere with each other both in terms of their use (Sakhartov, 2017) and in terms of the resulting corporate returns (Sakhartov and Folta, 2014). These mechanisms are involved in the present study, and their implications unique to the risk-return relationship are spelled out using a formal model. The use of the formalism provides the advantages of precision and of logical consistency (Adner *et al*., 2009; Hannah *et al*., 2018). The advanced precision of the formal model supports the articulation of the complex casual mechanisms. In turn, the logical consistency based on the principle of dynamic optimality (Bellman, 1957) prevents substantial biases in analyzing economies of scope from resource redeployment (Sakhartov and Folta, 2014) and overcomes the limitations of verbal theorizing on this complex inter-temporal phenomenon (Ghemawat and Cassiman, 2007).

Keeping to the promise to synthesize various mechanisms, this study sequences analyses as follows. First, inter-temporal economies from resource redeployment are disallowed, and the analysis focuses solely on intra-temporal economies from resource sharing. Second, intra-temporal economies from resource sharing are disallowed, and the examination is restricted to inter-temporal economies from resource redeployment. Finally, the interplay of the two types of economies, present at once, is analyzed. That synthesis is proven worthwhile. Notably, as Figure 11 summarizes, without such a synthesis, intra-temporal economies from resource sharing alone sustain a robust positive relationship between risk and return, and this relationship remains predominantly positive when diversification is based only on inter-temporal economies from resource redeployment. By contrast, the simultaneous presence of the two economies ensures the negative risk-return relationship, except for the combinations of weak relatedness with positive return correlation. Likewise, none of the two economies, when present in isolation, allows for the combination of the highest returns and of the lowest risk. However, when the two types of economies are present together, diversified firms can achieve the most favorable combination of the two performance measures if the combined businesses are very strongly related to each other and have strongly negatively correlated returns. Furthermore, even if the latter condition is not met, diversified firms can still enjoy high returns combined with relatively low levels of risk unless correlation is strongly positive.

Insert Figure 11 here

Beyond diagnosing these counterintuitive results, the model that synthesizes the two alternative mechanisms provides the following fundamental explanation. Relatedness involved in resource sharing unquestionably facilitates such sharing, which in turn leads to the enhancement of risk. Likewise, relatedness involved in resource redeployment enables such redeployment, which results in the considerable enhancement of risk. Given that both types of economies also lead to the increase in returns, a positive association between risk and results naturally follows this codetermination. What happens with this codetermination when both types of economies of scope are present? Because redeployment of resources between two businesses in a diversified firm compromises the sharing of resources between them, stronger relatedness makes the firm choose which of the two economies of scope to use. When relatedness is very strong, the permanently present benefit of sharing resources outweighs the optional benefit of redeployment. Accordingly, the use of resource sharing and the avoidance of resource redeployment reduces risk well below the level that would occur if redeployment were committed, so much below that this reduction surpasses the positive impact of relatedness on risk due to resource sharing. As a result, the ultimate effect of relatedness turns negative, whereas the effect of relatedness on returns remain positive. In other words, risk starts to decline in the direction of stronger relatedness, in which returns continue to grow, thus leading to the "paradoxical" negative risk-return relationship. This pattern breaks down only when return correlation is strongly positive because, in this case, returns in a firm's businesses converge to each other and redeployment of resources between them is unlikely anyway. In this limited case, relatedness involved in resource sharing assumes its natural positive effect that is codirected with its effect on returns. The conditions for the negative risk-return relationship and for the combination of high returns with low risk in diversified firms that are derived and explained in this study lay the groundwork for better empirical tests and facilitate better decision making by corporate managers.

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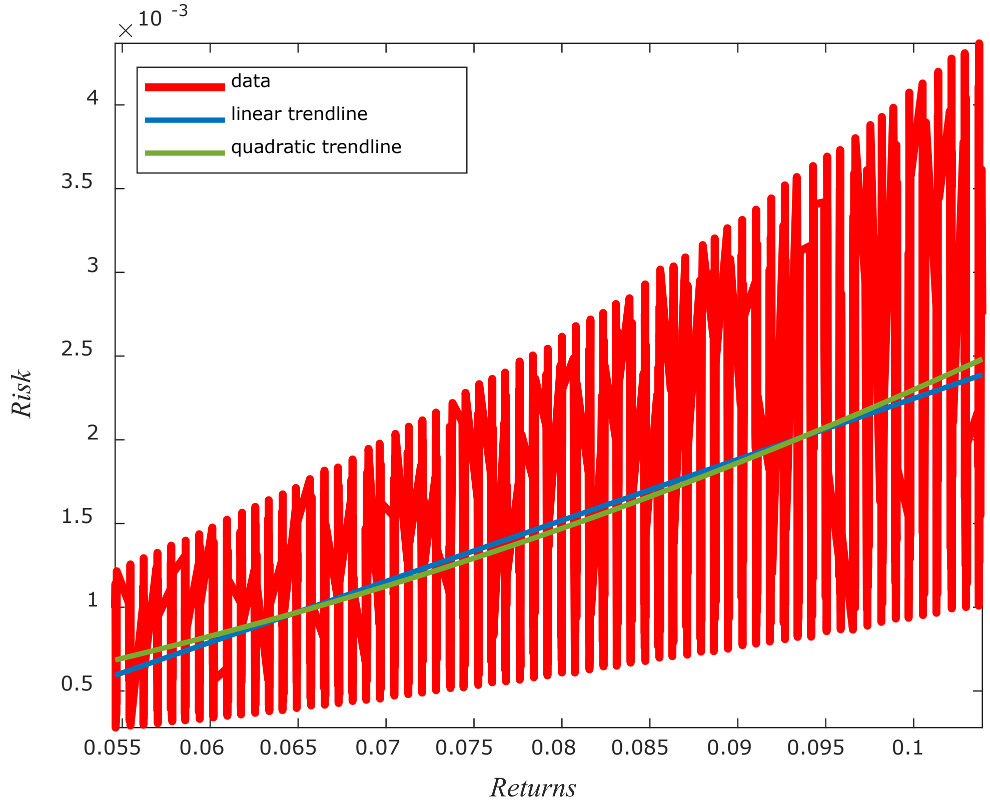
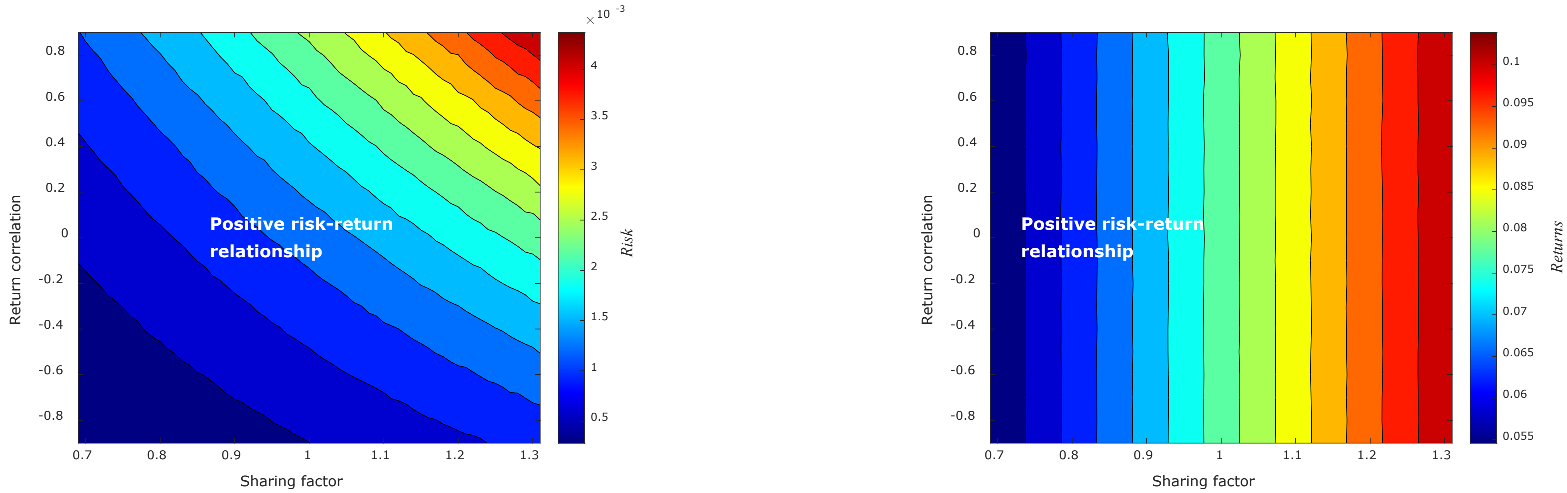


Figure 1. Risk-return relationship for various combinations of relatedness involved in resource sharing and of return correlation (economies from resource redeployment are absent)



A. Corporate risk **B. Corporate returns**

Figure 2. Corporate risk and corporate returns for various combinations of relatedness involved in resource sharing and of return correlation (economies from resource redeployment are absent)

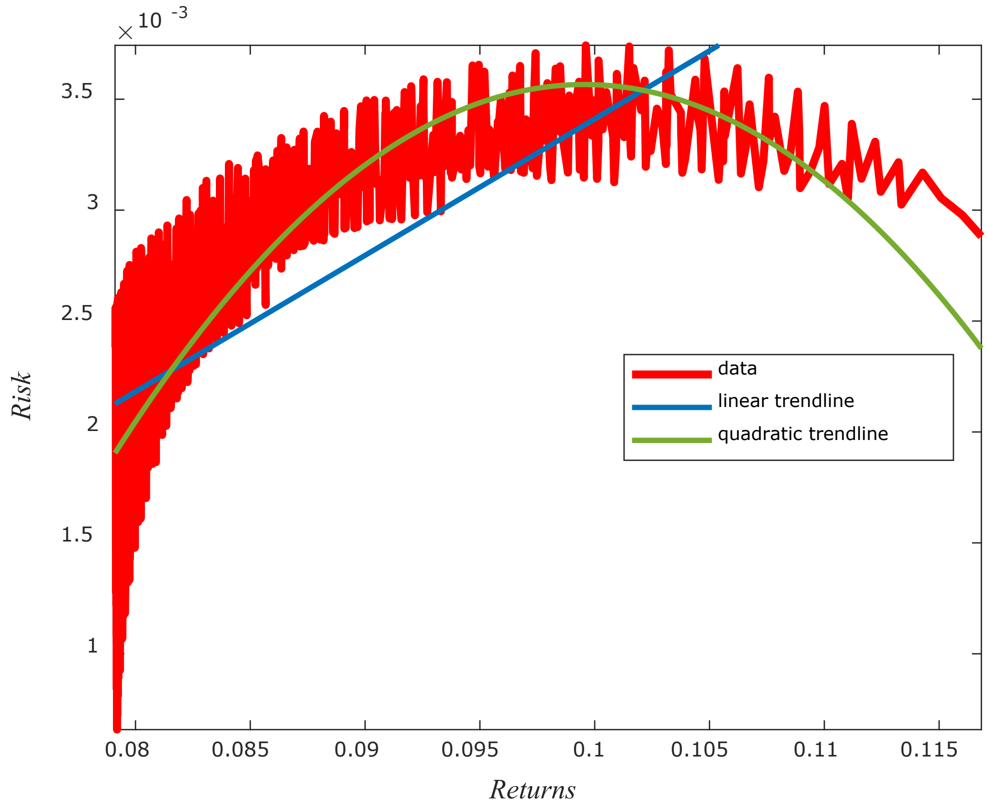
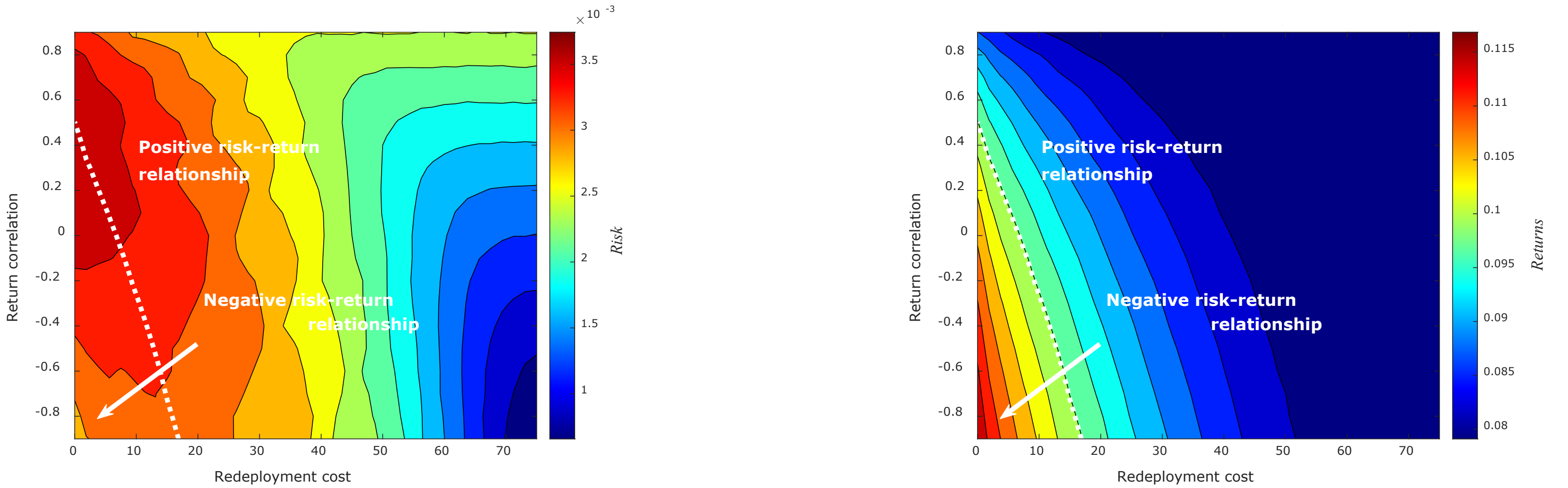
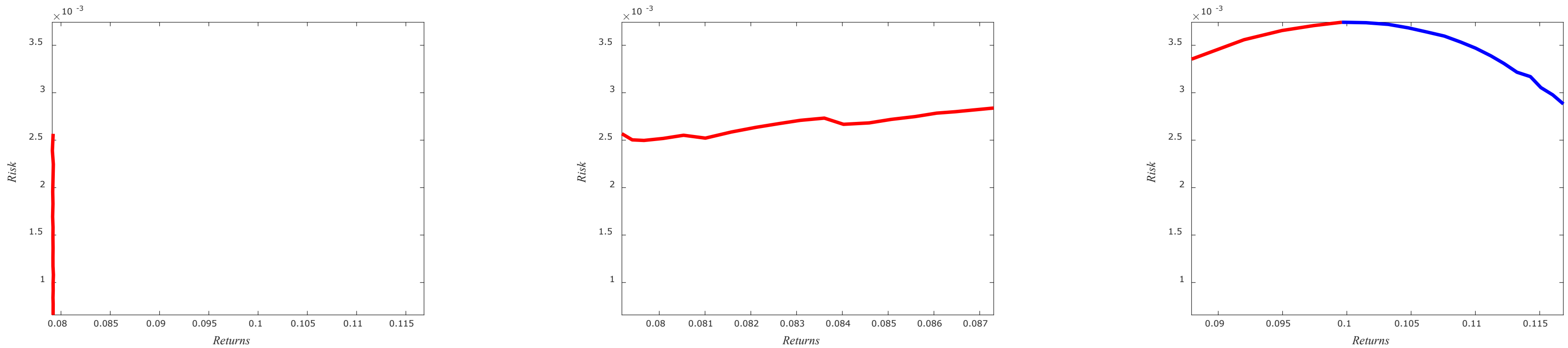


Figure 3. Risk-return relationship for various combinations of relatedness involved in resource redeployment and of return correlation (economies from resource sharing are absent)



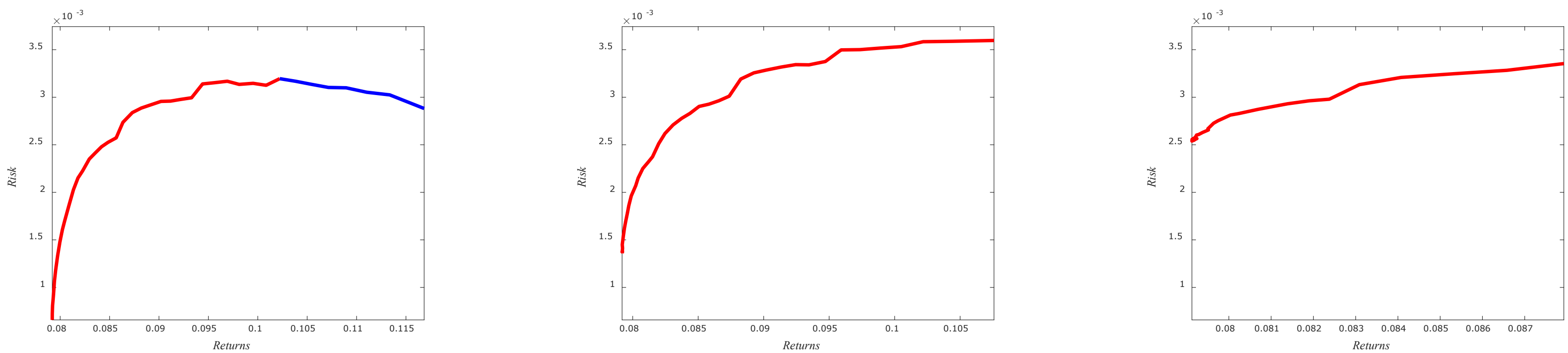
A. Corporate risk **B. Corporate returns**

Figure 4. Corporate risk and corporate returns for various combinations of relatedness involved in resource redeployment and of return correlation (economies from resource sharing are absent



A. High redeployment cost **B. Medium redeployment cost** **C. Low redeployment cost**

Figure 5. Risk-return relationship for three levels of relatedness involved in resource redeployment (return correlation varies)



A. Strong negative correlation **B. Zero correlation** **C. Strong positive correlation**

Figure 6. Risk-return relationship for three levels of return correlation (relatedness involved in resource redeployment varies)

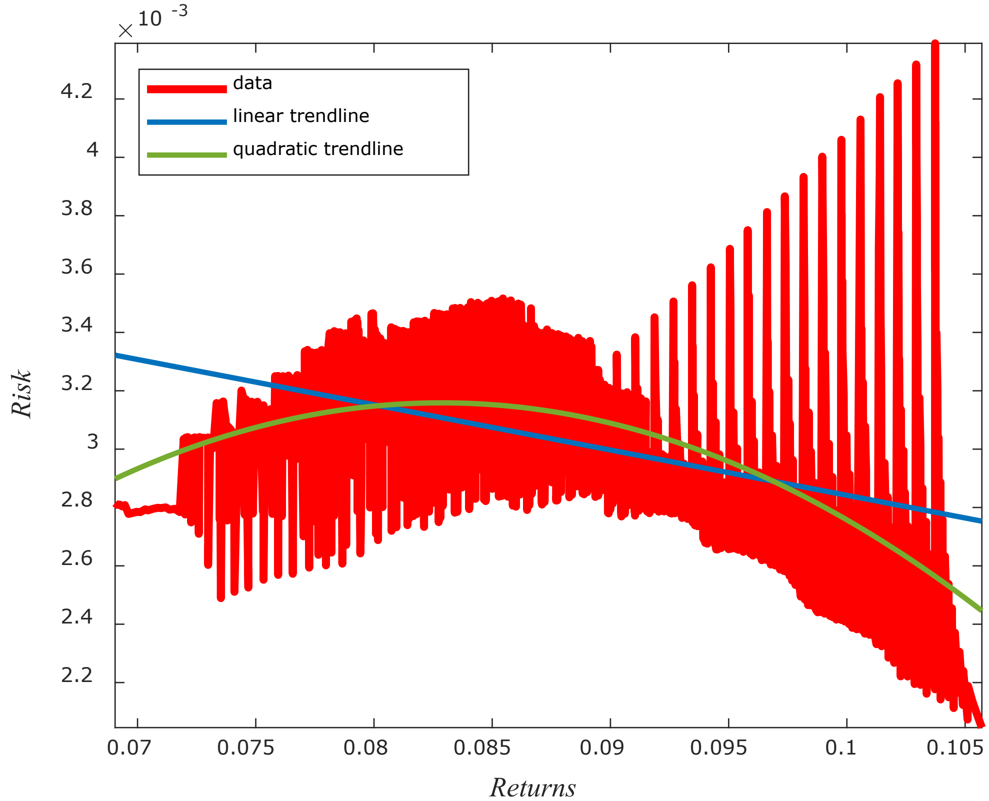
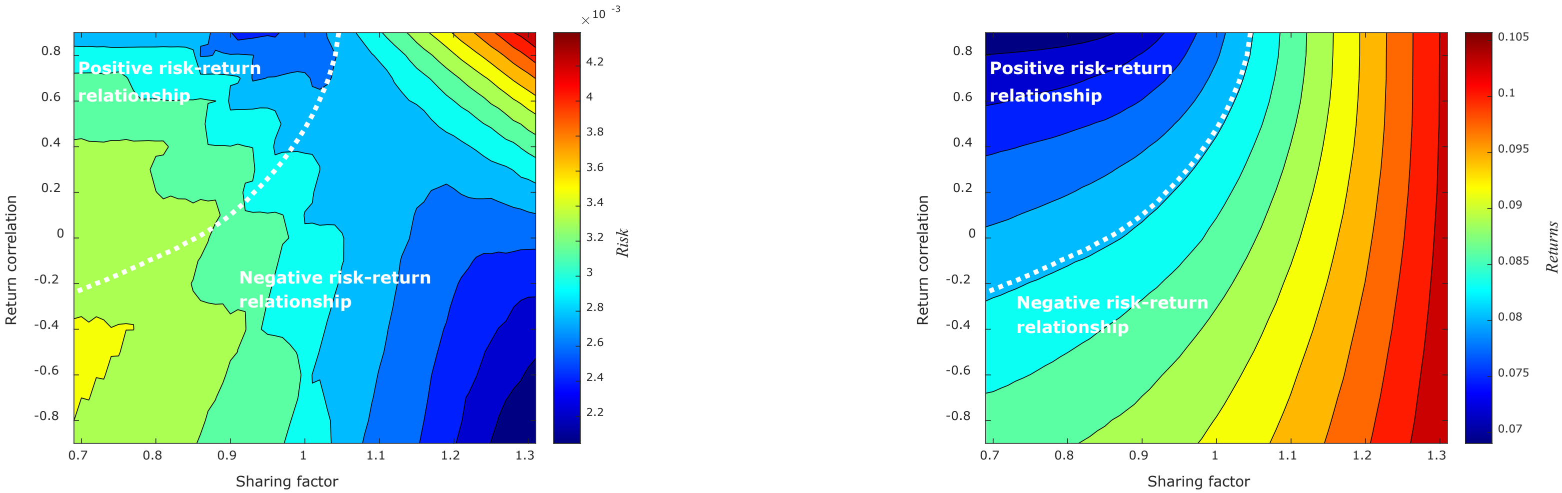
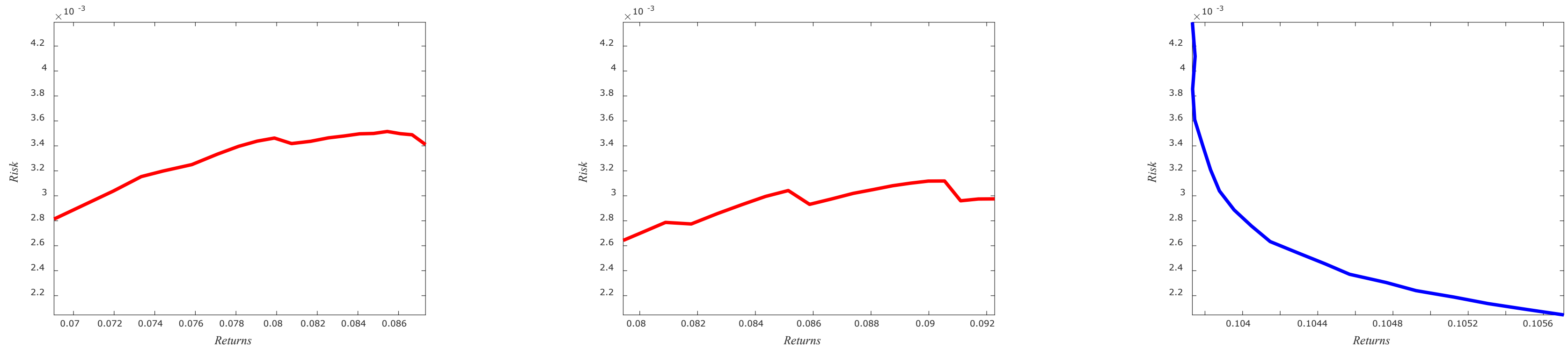


Figure 7. Risk-return relationship for various combinations of relatedness involved in resource sharing and of return correlation



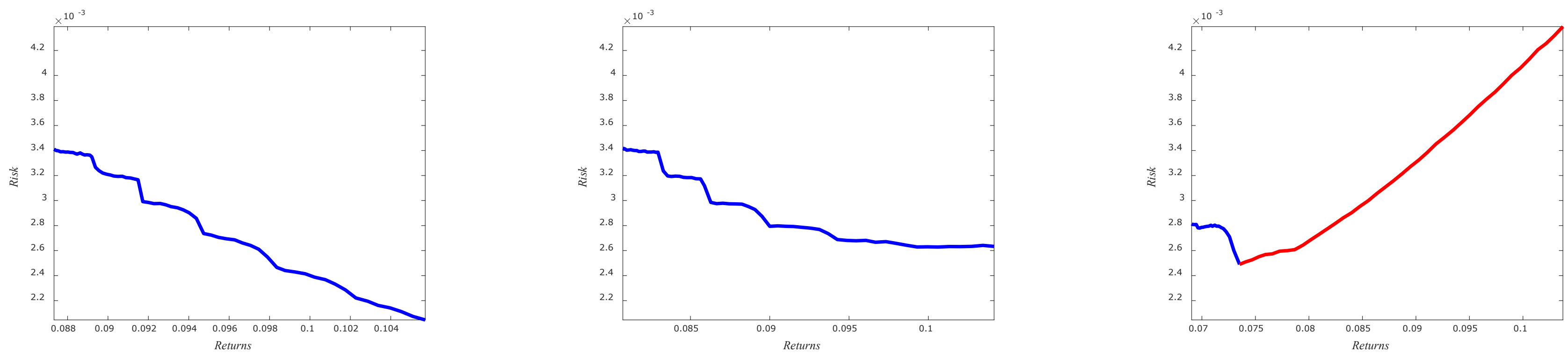
A. Corporate risk **B. Corporate returns**

Figure 8. Corporate risk and corporate returns for various combinations of relatedness involved in resource sharing and of return correlation



D. Low sharing factor **E. Medium sharing factor** **F. High sharing factor**

Figure 9. Risk-return relationship for three levels of relatedness involved in resource sharing (return correlation varies)



D. Strong negative correlation **E. Zero correlation** **F. Strong positive correlation**

Figure 10. Risk-return relationship for three levels of return correlation (relatedness involved in resource sharing varies)

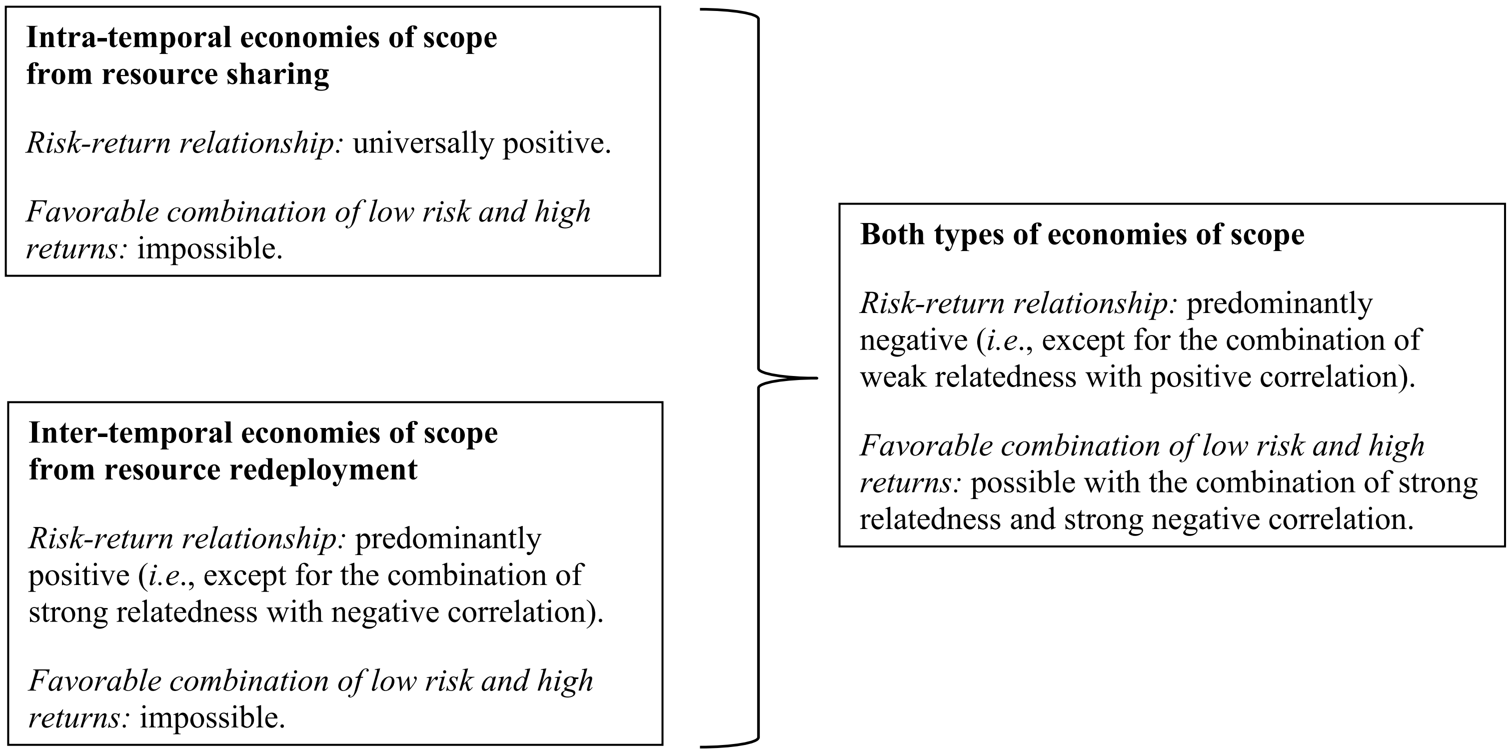


Figure 11. Summary of results