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Abstract: Using a new database of 391 interviews of French SME managers, this paper investigates the consistency of the Miller indicator of entrepreneurial orientation by relying on Sono-Leontief conditions. The main results suggest that Miller's construct is impacted by internal effects that cast doubts on its internal reliability, and that multidimensional assessments of entrepreneurial orientation should be preferred in empirical research

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1. Introduction

Entrepreneurial orientation (EO)[1] is a vibrant research topic (Covin and Wales, 2018), leading to a proliferation of research questions and studies (Wales, 2016), which encourage us to consider that EO is a "predominant construct of interest in strategic entrepreneurship research" (Anderson et al., 2015: 1579) and even in management sciences (Gupta and Gupta, 2015). However, there is still no consensus among scholars on how to measure EO (Covin and Lumpkin, 2011; Covin and Wales, 2012, 2018; George, 2011).

Following Miller (1983) and Covin and Slevin (1989), prior empirical research has mainly assessed EO as a unidimensional construct[2] derived from three primary dimensions: innovativeness, risk-taking, and proactiveness (Saeed et al., 2014). Since Covin and Slevin (1989) it has generally been posited that these three dimensions could be aggregated (i.e. summed with equal weights) in order to assess the overall level of a firm's EO. George (2011: 1293) emphasizes that 34 out of the 39 empirical studies he has found on this topic use this aggregative measure.

This approach has nevertheless been strongly challenged over the years, mainly because it assumes that these three components of EO (innovativeness, risk-taking, and proactiveness) can be conceptualized as substitutes for the construct. Lumpkin and Dess (1996), for instance, have suggested that EO is a multidimensional construct, in which each of the five dimensions they differentiate[3] can vary independently. Following this line, Hughes and Morgan (2007) emphasize that "proactiveness and innovativeness have a positive influence on business

[1] According to Miller (1983), "An entrepreneurial firm is one that engages in product-market innovation, undertakes somewhat risky ventures, and is first to come up with 'proactive' innovations, beating competitors to the punch" (p. 771).

[2] In this paper we use the terms construct, aggregate and indicator synonymously.

[3] They add competitive aggressiveness and autonomy to the canonical Miller model: innovation, risk-taking, proactiveness.

performance while risk-taking has a negative relationship," challenging Miller's conceptualization of EO (George and Marino, 2011) and opening the way for measurement models (George, 2011; Covin and Wales, 2011). Several scholars even stress the need to "reconceptualize EO," for instance by distinguishing between entrepreneurial behaviors (that encompass innovativeness and proactiveness) and managerial attitude toward risk (risk-taking) (Anderson et al., 2015), or by taking into account the contextual dimensions of the firm and the need to focus more on configurations of EO than on a single generic construct (Hughes et al., 2007, Kearney et al., 2018).

We propose to test the reliability of Miller's construct to address these debates about EO indicators. In management research, the reliability of composite indicators is usually assessed using empirical procedures (Chandler and Lyons, 2001), such as Cronbach alphas or confirmatory data analysis, which mainly investigate the correlations among items. As such, most of the existing indicators currently suffer from a lack of methodological foundation, as they do not indicate anything about the way the items included in the construct actually interact together. From this perspective, we think that a better assessment of the reliability of these constructs will be useful in order to check the internal consistency of past and future research that relies on these constructs and, from a broader perspective, to enhance "transparency in management research" (Aguinis et al., 2018).

The question of the validity of composite indicators was raised—and answered—a long time ago in economics during the controversy about the nature of capital aggregates (Cohen and Harcourt, 2003). A common way to assess if an aggregated indicator holds is to evaluate whether the Sono-Leontief conditions are met (Sono, 1945; Leontief, 1947a, 1947b). The aim is to assess if all the information carried by sub-indicators (or items) can be summarized in the

composite or if, to some extent, sub–indicators still convey information independently, even when these dimensions are conflated. Thus the aim of this paper is to evaluate if Miller's construct passes the Sono-Leontief conditions and should be considered valid from a methodological point of view.

Our paper follows a conventional structure. Section two introduces our methodology. Section three presents the collected dataset and variables and the empirical strategy. Econometric estimates are presented in section four. The final section suggests avenues for future research and concludes.

2. Methodology

The Sono-Leontief conditions hold that, in order for a composite indicator to be valid, it is necessary that its impact on a chosen dependent variable remains constant whatever its internal composition. In our case, this would mean, for instance, that when dealing with firm performance, a change in the relative composition of EO (among innovativeness, risk-taking, and proactiveness) should have no impact on firm performance, taking the overall level of EO constant.[4] Previous literature has mainly tested the validity of EO indicators by focusing only on the impact of their level on a chosen dependent variable. We propose here to develop an alternative perspective that tests the impact of both the level and the internal structure of EO indicators on the dependent variable in order to challenge their validity.

Formally, the Sono-Leontief conditions (also known as separability conditions) state that, with $Y(x_1, x_2,\ldots,x_n)$ a function that is continuously twice differentiable, $A(x_1, \ldots, x_k)$ and

[4] Composition effects should be assessed in both linear and non-linear ways.

G(A(x_1, …, xk), x_{k+1},..., x_n), can be defined such that Y(x_1,…, x_k,…, x_n)=G(A(x_1, …, xk), x_{k+1},..., x_n) if and only if Y has the property $\frac{\partial\left(Y_{i\in[1,k]}/Y_{j\neq i\in[1,k]}\right)}{\partial x_{z\in[k+1,n]}}=0,\forall i,j,z$, where the subscripts denote differentiation (Sono, 1945; Leontief, 1947a; 1947b).

In order to check empirically if the Sono-Leontief conditions are met for an existing aggregate, Aizcorbe (1990) suggests reshaping the function Y by including some mix functions M_m in order to recover the information lost due to aggregation, and then to test the validity of the associated coefficients using regression models.

More precisely, Y can be restated as Y=H(A(x_1, …, x_k), M_1,…, M_{k-1}, x_{k+1},..., x_n) where the mix functions $M_1 = M_l(x_1, x_k)$, $M_2 = M_2(x_2, x_k)$,…, $M_{k-1} = M_{k-1}(x_{k-1}, x_k)$ have been included as independent variables next to A(.).

Aizcorbe (1990) shows that if the indicator function A(.) is increasing in all inputs and the mix functions M_m , m Є [1, k-1] are differentiable, homogeneous-of-degree-zero functions with non-zero first partials that are specified so as to be independent from each other and from A(.), then the separability condition holds if and only if

$$\frac{\partial H}{\partial M_m}=0,\forall m\in[1,k-1]$$

This condition suggests that the indicator is valid from a methodological point of view if and only if the coefficients of the mix variables incorporated in a valid empirical model are not significant, regardless of the functional forms used for them.

Put differently, these conditions state that an aggregate is valid if and only if the explained outcome Y is impacted by the aggregate A but not by the mix effects M_m. This also means that the value of Y should not vary when the respective contributions of the sub-indicators are changed, while the value of the aggregate remains unchanged. Moreover this result should hold whatever the nature of the effects of the mix variables on Y (Aizcorbe, 1990).

It follows that the aggregate is valid if variables that assess the internal structure of the aggregate, understood as the way components may interact together (complementarity or substitutability), are never significant in valid empirical models.

Turning back to EO assessment, the Sono-Leontief conditions require Miller's construct to encompass all the information on EO level *and structure*, and that its effect on a chosen dependent variable should not vary when one change is made to its internal structure by replacing one component with another (for instance, by replacing some proactiveness with the "same amount" of innovativeness, so as to keep the value of the aggregate unchanged).

3. Empirical model, data, and variables

3.1. Empirical model

In order to investigate the internal consistency of Miller's EO construct, we focus on the following model, which aims to explain firm performance (Wiklund and Shepherd, 2005) and where two mix functions M_1(Risk, Innovation) and M_2(Proactiveness, Innovation) have been added[5]:

[5] As Miller's indicator encompasses three items, only two mix variables can be incorporated in the model to assess the composition effects. As an example, we have chosen to focus on the relationships between Risk and Innovation and Proactiveness and Innovation. The results remain the same with models that also encompass M_3 = (Risk/Proactiveness). These results are available on request from the authors.

Firm Performance = β_1 Firm Size+ β_2 Firm Age + β_3 Miller's EO construct + β_4 Industrial Dynamism + β_5 Financial Constraints + β_6 M_1 + β_7 M_2 + γ+ ε where γ denotes the sectoral effects and ε is a random error.

At first glance, all the estimations are performed here using the OLS method. If the aggregate is valid, then the proposition H_0: $\beta_6 = \beta_7 = 0$ should hold whatever functional form is used for the mix variables.

3.2. Data and variables

The data come from the Association Ariane Compétences et Management (Ariane CM), which launched a robustly methodological survey in connection with the Fondation Nationale pour l'Enseignement de la Gestion des Entreprises (FNEGE)[6] in 2011 in order to investigate the characteristics of French SME managers and to compare them with their European counterparts.

The survey was elaborated by a steering committee formed from members of Ariane CM (former CEOs and board representatives of French firms), FNEGE (senior scholars in management sciences), and TNS SOFRES[7] to highlight manager profiles, management practices and performance in French SMEs. Emphasis was placed on the EO of SMEs, as it seemed important to understand the internal dynamics of a firm. It was decided to measure EO using the seven-item index developed and validated by Miller (1983), which has been widely used and seen as reliable, specifically in the context of SMEs (Zahra et al., 2000, Zahra et al., 2004). The questionnaire was pre-tested on an initial sample to check for the

[6] The French Foundation for Management Education.

[7] TNS SOFRES (now Kantar TNS) is the leading data collection firm in the French market.

clarity and relevance of its content. We deleted the question from the survey that SME managers generally reported that they didn't understand".

We assembled a sample of independent SMEs with 10 to 249 employees, representative of the whole population of French SMEs, as identified by the French National Institute of Statistics (INSEE). SMEs were selected using strata on regions and firm size.

Data were collected by TNS SOFRES through telephone calls to SME managers between April 18 and May 23, 2012.[8] The database encompassed more than 450 observations but the final sample was reduced to 391 observations, due to missing variables. Possible non-response bias was checked and the final sample appeared to be random.

An important point to note is that respondents were firms' owners or general managers of SMEs, who appeared to be "key managers" (Miller, 1983, Covin and Miller, 2014). These managers were in a central position in the SME, and constituted "the key determinant of the strategic posture of the firm" (Miller, 1983: 94, quoted in Covin and Miller, 2014: 17). On this basis, we assume that their answers give an accurate depiction of the EO of their firm.

All the variables and descriptive statistics are summarized in Table 1.

[8] Note that TNS SOFRES arranged telephone appointments with SME managers to plan the administration of the questionnaire. Scholars were able to access the administration platform to obtain guarantees about the quality of the data collection process.

Table 1. Variables and descriptive statistics (N = 391)

Name of the variable	Description	Mean	sd	Min	Max
Firm Performance	Sum of the answers from the four following items (quoted 1: false, 2: true) 1. Our sales have increased over the past 3 years 2. Our market share has increased over the past 3 years 3. We have hired new wage earners over the past 3 years 4. Our profitability has increased over the past 3 years	6.38	1.35	4	8
Firm Size	Number of wage earners in the company	64.7	63.98	10	249
Firm Age	Firm age in years	36.33	31.05	1	338
Miller's EO construct	Sum of Risk, Innovation and Proactiveness	14.57	2.61	6	23
Industrial Dynamism	Sum of the answers from the four following items (quoted 1: totally false, 2: somewhat false, 3: somewhat true, 4: totally true) 1. In our industrial sector, competitors often change their tactics 2. In our industrial sector, clients demand change rapidly 3. In our industrial sector, legal changes are common 4. In our industrial sector, innovation is important	1.44	2.06	6	16
Financial Constraints	Answer to the following proposition (quoted 1: totally false, 2: somewhat false, 3: somewhat true, 4: totally true) My company can easily finance the development of a new project.	2.97	0.76	1	4
Risk	*Sum of answers from the two following items (quoted 1: totally false, 2: somewhat false, 3: somewhat true, 4: totally true)* *1. Our company accepts to deal with very risky projects* *2. Our company rewards calculated risk-taking*	*4.49*	*1.36*	*2*	*8*
Proactiveness	*Sum of the answers from two following items (quoted 1: totally false, 2: somewhat false, 3: somewhat true, 4: totally true)* *1. Our company attacks competitors on their market* *2. Our company targets long-term goals*	*5.71*	*1.20*	*2*	*8*
Innovation	*Sum of answers from the two following items (quoted 1: totally false, 2: somewhat false, 3: somewhat true, 4: totally true)* *1. Our company is the first one to introduce new products on the market* *2. Our company only uses well-known procedures and methods (reverse coding)*	*4.36*	*1.16*	*2*	*8*

4. Results

Due to the need for homogeneous-of-degree-zero functions, the mix functions of Miller's EO construct can only be derived from ratios of items chosen between the Risk, Innovation and Proactiveness items. As an example we focus here on $M_1 = f_1$ (Risk/Innovation) and $M_2 = f_2$ (Proactiveness/Innovation), f_1 and f_2 being functions to be defined.[9]

First the test is displayed using three kinds of functional forms for f_1 and f_2 (identity, log and exponential) that assess respectively constant, decreasing and increasing returns in the way sub-indicators interact together. Table 2 shows that the requirement to pass the F-test of H_0 is never met, whatever the functional form is chosen for the mix variables. But if there is not enough evidence here to reject the assumption that Miller's construct is valid, Model 3 also suggests that the mix variables fit better with exponential functional forms.

[9] Other formulations, such as item percentages, lead to similar results that are available on request from the authors.

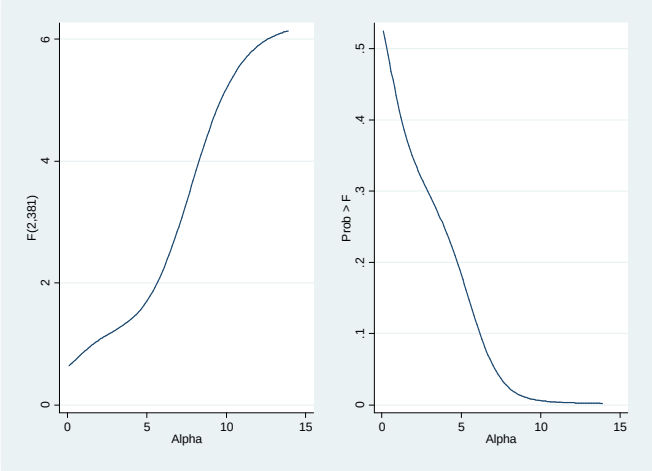
Table 2. Regression results

Variables	Model 1	Model 2	Model 3	Model 4
Firm Size	0,003***	0,003***	0,003***	0,003***
	0,001	*0,001*	*0,001*	*0,001*
Firm Age	-0,004	-0,005	-0,004	-0,005
	0,003	*0,003*	*0,003*	*0,003*
Miller's EO construct	0,064***	0,07***	0,071***	0,070***
	0,026	*0,027*	*0,026*	*0,027*
Industrial Dynamism	0,025	0,019	0,021	0,020
	0,033	*0,033*	*0,033*	*0,033*
Financial Constraints	0,331***	0,326***	0,322***	0,324***
	0,092	*0,093*	*0,093*	*0,093*
Risk/Innovation		0,316		
		0,170		
Proactiveness/Innovation		-0,041		
		0,163		
***Exp (*Risk/Innovation)**			-0,001	
			0,018	
***Exp (*Proactiveness/Innovation)**			0,016*	
			0,009	
***Log (*Risk/Innovation)**				0,044
				0,211
***Log (*Proactiveness/Innovation)**				-0,240
				0,233
Constant	4,06***	3,831***	3,951***	4,014***
	0,542	*0,573*	*0,549*	*0,549*
F-statistic	6.87***	5.49***	5.68***	5.42***
R^2	0,106	0,110	0,111	0,109
Number of observations	391	391	391	391
F-test of H_0	-	0.83^{ns}	1.46^{ns}	0.62^{ns}

*Sectoral dummies included * p<0.1; ** p<0.05; *** p<0.01*
Standard errors in italics

To verify this point, the test was again displayed using a more general exponential form. M_1 = (Risk/Innovation)$^{\alpha}$ and M_2 = (Proactiveness/Innovation)$^{\alpha}$ were defined and the test was computed for α ranging from 0.1 to 15. Figure 1 shows the evolution of the F-statistic associated with H_0, as well as its significance level.

The results of the simulation suggest that the coefficients of M_1 and M_2 both turn out to be significant for α higher than 6, the first being negative and the second positive. This last point suggests that, independently of the firm's EO level, high levels of risk-taking may have an adverse effect on firm performance if they do not lead to high levels of innovation. The opposite appears to be true for the relationship between levels of proactiveness and innovation. A key point is that the effect on firm performance is significant when the three items do not covary. Up to a point these results suggest some weak complementarity between the three dimensions incorporated in Miller's indicator. As H_0 is validated, Miller's EO indicator no longer appears to meet the separability conditions and there is enough evidence to cast doubt on its methodological consistency.



M_1 = (Risk/Innovation)$^{\alpha}$ and M_2 = (Proactiveness/Innovation)$^{\alpha}$

Figure 1. F statistics and significance levels of the mix variables

5. Discussion and conclusion

5.1 Contributions, limitations, and implications for future research

Enhancing methodological transparency remains a clear issue in management research (Aguinis et al., 2018). While it is usual to test statistically the reliability of composite

indicators in managerial studies (e.g., with Cronbach alphas), it is now necessary to go beyond empirical approaches to challenge the methodological foundations of these constructs.

Sono-Leontief conditions are of obvious interest here, because they directly address the ability of the indicators to summarize all the information deriving from their components. Applied to EO, our empirical results suggest that while Miller's EO indicator may meet some theoretical issues, the separability conditions are not met, signifying that the Miller index neither properly nor completely addresses the EO phenomenon. More precisely, the significance of the mix variables indicates that some combinations of components can have an additional impact on firm performance, outside Miller's indicator.

It is necessary to go one step further to understand the reasons and consequences of our results. The three components— – proactiveness, innovation, and risk-taking – do not appear to be substitute elements of EO.[10] In view of this, a better understanding of their true nature appears to be essential.

But "reconceptualizing EO" (Anderson et al., 2015) appears equally necessary in order to highlight both the connections between proactiveness, innovation and risk-taking, possibly by differentiating the elements (see Anderson et al., 2015), and the connection between EO and firm performance. Contingency factors (Hughes and Morgan, 2007, Hughes et al., 2007, Lumpkin and Dess, 2001), and configurational dimensions that can have an impact (Linton and Kask, 2017, Kearney et al., 2018) need to be scrutinized to understand better the nature and the consequences of EO for firms.

[10] It would also be interesting to provide additional analysis of the variables metric in order to refine the conclusions.

Our research is not without limitations. First, testing for Sono-Leontief conditions requires choosing a valid empirical model where the indicator has an acknowledged impact on the dependent variable. Results should then be robust when switching from one model to another, and it would be interesting to see if our conclusions hold when focusing on the impact of EO on, for example, innovation or firm governance. Moreover, the empirical test proposed here relies on a rather simple formalization of the relationship between EO and performance, with only a few moderator variables. It would be informative to see if our conclusions remain unchanged after the inclusion of variables that refer, for instance, to the characteristics of top management teams (Richard et al., 2009), leadership behavior (Engelen et al, 2014), or the environment of the firm (Dess et al., 1997, Zhara, 1991). Estimation methods could also be refined, especially when dealing with complex (non-linear) mix variables.

Last but not least, testing all the possible functional forms for the mixed variables can be problematic when the number of items in the indicator becomes significant, as the number of mixed variables will grow exponentially. The Sono-Leontief method is better adapted to testing simple aggregates that encompass only a limited number of items.

5.2 Conclusion

Assessing organizational phenomena for conducting empirical research can sometimes be problematic. We provide here a simple procedure to check the reliability of composite indicators, as well as an application of Miller's EO empirical construct. From this perspective, we believe that our research leads to a deeper understanding of the true nature of composite indicators, and opens new perspectives for scholars involved in EO research.

While our results—which emphasize that the Miller index does not pass the Sono-Leontief conditions—may be puzzling, considering past research on this topic, it should be regarded

more as a way to refine our understanding of the EO phenomenon than as a radical critique of its interest.

But if previous EO research has conveyed first-hand results regarding the entrepreneurial position of the firm, we also need to be aware that focusing on the Miller index may be somewhat misleading, as it conveys the risk of missing some important issues in the way EO components interact together.

Our results open new perspectives for future research as they suggest that multidimensional assessments of EO should be considered, as well as contingency and configurational effects (Lumpkin and Dess, 1996, Anderson et al., 2015). Our findings also call for a reexamination of a large part of the empirical literature that includes EO as a strategic determinant of organizational behavior by relying on Miller's construct (Rauch et al., 2009, Seed et al., 2014).

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