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Overstating and understating interaction results in international business research

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ABSTRACT

Approximately one-third of international business (IB) articles include conditional hypotheses, yet the vast majority risk errors in testing or interpreting the results. Scholars typically restrict their empirical analysis to the coefficient of the interaction term in the regression, exposing themselves to the hazard of overstating or understating results. To mitigate the risk of misstating, we advocate that IB scholars also evaluate the statistical significance of the marginal effect of the primary independent variable over the range of values of the moderating variable. We demonstrate that overstating results can occur when the interaction term coefficient is statistically significant but the marginal effect is not significantly different from zero for some value(s) of the moderating variable. Understating can occur when the interaction term coefficient is not statistically significant, but the marginal effect is statistically different from zero for some value(s) of the moderating variable. In this article, we describe, using simulated data, these two possibilities associated with testing conditional hypotheses, and offer practical guidance for IB scholars.

1. Introduction

International business (IB) theory often includes conditional hypotheses. A conditional theory reflects scholars' recognition of the need to include a moderating variable in a proposed cause-and-effect relationship. The output of such theorizing takes the form of a hypothesis in which the relationship between a dependent variable and a primary explanatory variable of interest varies across the level or existence of some other moderating variable. To test a conditional hypothesis, researchers typically specify a regression model that includes a multiplicative interaction term. However, despite the growing number of articles containing such terms, IB researchers rarely distinguish – either conceptually or statistically – between two very different questions in their analysis of moderated relationships (Aiken & West, 1991).

Commonly, researchers ask only the following question: is the estimated coefficient on the interaction term in the regression statistically significant? If yes, then they generally conclude that support exists for the conditional hypothesis. However, IB researchers seldom explore a second, equally important question identified in the literature as contributing to a more complete test of the conditional hypothesis (e.g. Brambor, Clarke, & Golder, 2006; Berry, Golder, & Milton, 2012; Spiller, Fitzsimmons, Lynch, & McClelland, 2013). This question asks: is the effect of a change in the primary explanatory variable on the dependent variable (or, more simply, the "marginal effect" or "regression slope"), for any specific value of the moderating variable, statistically different from zero? The answer to the latter question provides vitally important additional information about the support for a conditional hypothesis. Whereas the first question asks whether marginal effects differ from *one another* for any two values of a moderating variable, the second question asks whether a marginal effect *differs from zero* for any specific value of a moderating variable (Aiken & West, 1991).

Differentiating between the two questions is critical. As we demonstrate in this paper, it is entirely possible to find, simultaneously, that the estimated coefficient on an interaction term is statistically insignificant *and* that the effect of a change in the primary explanatory variable (i.e., the marginal effect) is statistically different from zero over some portion of the range of the moderating variable. It is also possible for the researcher to find a statistically significant estimated interaction coefficient *but* that the effects of a change in the explanatory variable are significantly

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different from zero for only some value(s) of the moderating variable.

A key implication – and the central point of this paper – is that failure to address both questions exposes IB scholars to the potential hazard of either *understating* or *overstating* empirical support for the conditional hypothesis. Understating may occur if researchers discard a conditional hypothesis based on obtaining a non-significant coefficient on the interaction term (Question 1), because they may miss seeing a statistically significant non-zero marginal effect of the primary explanatory variable for some value (s) of the moderating variable (Question 2). Overstating may occur if researchers go no further than to report a statistically significant interaction coefficient when, simultaneously, the marginal effect of the primary explanatory variable for one or more values of the moderating variable is not different from zero.

The approach that we advocate in this paper, by virtue of the different information content embedded in the different tests, is for the researcher to ask both questions. Correctly testing and interpreting interactions matters to the development and advancement of IB theory and practice. If scholars overstate, the field may be exposed to believing some causal relationships hold across more cases than is true, potentially causing managers to make misinformed decisions. Equally if not more damaging, if scholars understate, the field may be systematically losing important information about the state of the world, and distorting managerial practice. The questions international business scholars ask are important and nuanced, and doing justice to those questions requires not only building theories but employing appropriate statistical tests. Good theory yields better practice.

In the remaining pages, we discuss the importance of addressing these two questions to avoid overstating and understating the evidence of conditional effects. The following section details the statistical terminology and technicalities associated with empirically testing the two questions. We then review empirical research in IB to show that researchers typically do not explore interactions as advocated in this paper. In the next section, using simulated data on 200 firms considering how to best grow their direct investment in a foreign country, we walk step-by-step through several illustrative tests and interpretations of interaction models. We also show that the risk of overstating and understating is potentially quite large. The paper concludes by offering statistically sound and approachable recommendations to help IB scholars draw appropriate inferences in tests of interactions.

2. Defining interactions

In this section, we explore more deeply the technicalities of these two questions, and introduce terminology that we use throughout the remainder of the paper.

Recall the first question: is the estimated regression coefficient on the interaction term statistically significant? This question asks whether there is a statistically discernible difference between the marginal effect of a primary explanatory variable across different values of the moderating variable ("Question 1"). Scholars often refer to Question 1 as testing for an "interaction" effect. Consider the case of a researcher with a dichotomous (or binary) moderating variable. To empirically test whether two marginal effects are statistically distinguishable across "high" versus "low" values of the moderating variable, the researcher may specify an interaction model of the form:

$$Y = \beta_0 + \beta_1 X + \beta_2 Z + \beta_3 XZ \quad (1)$$

where:

X is a (continuous) explanatory variable of interest,

Z is a dichotomous moderating variable (taking on the value 0 or 1),

Y is a continuous dependent variable.

The marginal effect of X on Y, sometimes referred to as the "simple slope," in Eq. (1) is given by:

$$\frac{\delta y}{\delta x} = \beta_1 + \beta_3 Z (\text{i.e., the derivative of Y with respect to X}) \quad (2)$$

From Eq. (2), the marginal effect of X on Y is a function of a third variable, Z. Given an interaction model such as Eq. (1), it is not appropriate to speak of a single, unconditional marginal effect of X on Y (Brambor et al., 2006; Spiller et al., 2013; Aguinis, Edwards, & Bradley, 2016). When Z is dichotomous, there are two marginal effects to consider (or, as discussed below, when Z is continuous there is a range of marginal effects corresponding to different values of Z).

$$\text{So, when } Z = 0: \frac{\delta y}{\delta x} = \beta_1 + \beta_3(0) = \beta_1$$

$$\text{Similarly, when } Z = 1: \frac{\delta y}{\delta x} = \beta_1 + \beta_3(1) = \beta_1 + \beta_3$$

The difference between the two marginal effects is given by $(\beta_1 + \beta_3) - \beta_1 = \beta_3$. If the estimate of the interaction coefficient β_3 is statistically significant (determined by comparing it to its standard error), one can conclude that the two marginal effects (corresponding to Z = 0 and Z = 1) are discernibly (statistically) different from each other.

Researchers with conditional hypotheses typically stop their analysis with this test of the statistical significance of β_3. The precise reasons for this are speculative, but it is common practice across many disciplines (Aguinis et al., 2016; Ai & Norton, 2003; Brambor et al., 2006; Spiller et al., 2013). As noted, however, it is important that researchers go beyond simply testing Question 1; otherwise, they run the risk of understating or overstating support for the conditional hypothesis, which can serve to compromise the veracity and impact of the proposed theory.

Recall the second question: is the effect of a change in the primary explanatory variable on the dependent variable, for any specific value of the moderating variable, statistically different from zero? More precisely, the question asks, are the marginal effects of the primary explanatory variable statistically different from zero, for one, both, or neither level of the moderating variable? ("Question 2") To empirically test this (or any other null hypothesis-specified value), a researcher compares the marginal effect from Eq. (2) to its standard error. As shown above, the marginal effect when Z = 0 is simply represented by β_1, and the marginal effect when Z = 1 is represented by $\beta_1 + \beta_3$. If a marginal effect is not statistically different from zero, it means that there is no relationship between the explanatory variable of interest and the dependent variable at *that* specific value of the moderating variable.

It is entirely possible for the estimated $\hat{\beta}_3$ coefficient in an interaction model to be statistically significant, and hence for the marginal effects to be different from one another across the levels of the dichotomous moderating variable Z, and *yet* for the marginal effect of X on Y to be statistically distinguishable from zero for both, only one, or even neither of the two values of the moderator. Or, again in the dichotomous case, it is possible for the $\hat{\beta}_3$ in the interaction model to be statistically insignificant, so that there is no discernible difference in marginal effect across high and low value of the moderator Z, but at the same time for the marginal effect of X on Y to be statistically different from zero for neither, only one, or even both of the two values of the moderator. In the case of a model