Endogeneity in Accounting and Finance Research: Natural Experiments as a State-of-the-Art Solution

Abstract
This paper provides a discussion of endogeneity as it relates to finance and accounting research. We discuss the textbook solutions: two stage least squares, instrumental variables, differenced GMM and System GMM and provide a unifying framework showing how they are related. We consider the limitations of these techniques and then detail a state-of-the-art solution—utilizing a natural experiment as a way of mitigating endogeneity and building stronger theory.

Key words: Corporate governance, endogeneity, natural or quasi experiment

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Introduction

Endogeneity is more than a problem of econometrics. It is also a problem of theory. The issue for researchers is that often variables included in the structural equations are simultaneously determined, mismeasured and/or the theory is incomplete and so important variables are omitted. More sophisticated econometric techniques are only part of the solution. Better theory is also necessary to help researchers build more complete and accurately specified models.

In finance and accounting research it is important that empirical work is underpinned by theory. Accordingly a well designed study must be clear about how and why variables influence one another and the logic and direction of the relationship must be specified (Larcker & Rusticus, 2007). However, much of the accounting and finance empirical literature is plagued by endogeneity, particularly in corporate governance studies (Roberts & Whited, 2012). A spate of recent articles addressing the concerns of endogeneity in the finance and accounting literature is putting this issue firmly on the table. For example, Chenhall and Moers (2007), Larker and Rusticus (2007), and Van Lent (2007) in accounting. And in finance, Roberts and Whited (2012) and Brown, Beekes and Verhoeven (2011). Endogeneity has always been present and recognized as a problem that undermines causal inference. However, it is often a problem that researchers either do not address at all; or simply note in passing that the problem exists. Table 1 selects the papers with endogeneity issues published in 2013 & 2014 in Asian Pacific journals including: the Australian Journal of Management (9), Accounting and Finance (11), Abacus (1), Pacific Basin Finance Journal (2), and International Review of Finance (1). Out of the 24 papers listed in the Table, only 2 performed all specification tests and more than half (13) performed no tests.

Ignoring the problem, however; does not mitigate the implications—endogeneity limits the validity of empirical testing of models. Here, we do not question the validity of finance and accounting research to date to the extent that it should be disregarded. We argue that endogeneity has become more of a concern as we model increasingly complex relationships. Accordingly, the power of our theories are more keenly scrutinized and tested.

While all agree the problem is pervasive there is some disagreement about how best to deal with it. Chenhall and Moers (2007) and Larker and Rusticus (2007) argue that theory development is critical. Van Lent (2007) on the other hand, argues theory is never likely to be complete and good instruments are hard to find and so there is little a researcher can do to mitigate endogeneity. He argues good research should be judged by how stimulating the research question is and it is a mistake to pretend that models are fully specified. Researchers should rather defend why they chose that particular misspecification and articulate how the results would change had they chosen another misspecification of the model. Roberts and Whited (2012) emphasize the importance of researchers
discussing endogeneity along with good empirical design using high quality data and robust testing of empirical predictions. Researchers should not be discouraged from empirical testing because even if endogeneity is known to be present, such studies provide the foundation for future work (Roberts and Whited, 2011).

Where researchers recognize endogeneity as a limitation to their research, how they deal with it is constrained by current thinking on appropriate techniques. Commonly used research designs to deal with endogeneity include two stage least squares, instrumental variables, difference GMM and system GMM as we can see from Table 1. In section 2 of this paper we provide a unifying framework that illustrates and encompasses all of these approaches.

Looking beyond the textbook solutions, one research design, which helps mitigate the problem of endogeneity, is that utilizing a natural experiment. A study incorporating a natural experiment provides the researcher leverage over the commonly used textbook solutions to endogeneity because it involves making use of a plausibly exogenous source of variation in the independent variables of interest (Meyer, 1995). If the naturally occurring event is convincingly exogenous, and the study well implemented, then researchers have a way to isolate causal links, build new theory and clarify (confirm/disconfirm) existing theory by mitigating the issue of endogeneity. In this paper, we provide researchers a road map to designing research based on natural experiments and in this way we contribute to the evolution to more rigorous research techniques in finance and accounting.

**Endogeneity and current textbook solutions**

The current textbook solutions to endogeneity include two stage least squares (2SLS), instrumental variables (IV); difference general methods of moments (GMM); and system GMM. In the section that follows, we work through these methods and provide a unified framework showing how these approaches are related.

**What is endogeneity?** In terms of econometrics we can think of endogeneity as having several dimensions. First it is a problem of omitted variables i.e., variables other than the ones specified provide alternative or additional explanation for the relationship modelled. For example, the relationship between executive compensation and firm value intuitively depends on executives’ abilities, which is difficult to quantify (Roberts & Whited, 2012). Further, if looking at the value of independent directors, again, ability of the directors would be important but also it is difficult to

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1 Roberts and Whited (2011) discuss in great detail the issue of endogeneity and how it relates to the corporate governance literature.
measure independence, surely a function of director and CEO networks, which are not easy to establish.

Second, endogeneity is a problem of simultaneity i.e., when the dependent variable and one or more of the explanatory variables are jointly determined. For example, more police officers might reduce crime but cities with higher crime rates might demand more police officers; more diffuse firm ownership might affect performance but firms with strong performance might attract diffuse ownership; banks with adequate capital reserves might have good performance but good performing banks might have stronger capital reserves etc. In all such cases, results from regression analysis might confound these relationships because the direction of causality is most likely two ways.

A third problem is that related to measurement error when proxies are used for unobservable or difficult to measure independent or dependent variables (Roberts & Whited, 2012). For example, looking at the relationship between firm value and Board independence, researchers must proxy for the degree of independence from the CEO.

The following works through the current textbook approaches to endogeneity beginning with the errors in variables problem, which is familiar to most students or researchers in finance.

**Errors in variables problem** To understand endogeneity we can first liken it to the errors in variables problem. The following greatly simplifies this problem. Let’s define the relationship:

\[ Y = \alpha + \beta X + \mu \]

Where: \( X = X^* + \epsilon \)

i.e., \( X^* = \text{True value} \) and \( X \) measures \( X^* \) with error

This implies the X variable is not independent of the error and that omitted variables, which may be variables we are unaware of or simply cannot be quantified, are correlated with the error term.

Ordinary least squares (OLS) minimizes the sum of the squared errors

\[ L = E[(Y - \alpha - \beta X)^2] \]

This has the following first order conditions known as the normal equations of OLS:

\[ \frac{\partial L}{\partial \alpha} \rightarrow E[Y - \alpha - \beta X] = 0 \] (1)

\[ \frac{\partial L}{\partial \beta} \rightarrow E[Y - \alpha - \beta X]X = 0 \] (2)

We will show in this section that all of the econometric methods to address endogeneity can be thought of in terms of these normal equations of OLS. They will be the basis for moment conditions that define the GMM estimators. The approach will nest the maximum likelihood approach with the
advantage that the coefficients and standard errors will be the same if the maximum likelihood assumptions are correct but that the standard errors of the GMM approach will be valid whether or not the maximum likelihood assumptions are correct. Solving the normal equations of OLS—equations (1) and (2) above—yields the normal estimate:

$$\beta = \frac{\text{Cov}(Y, X)}{\text{Var}(X)}$$

Since X is measured with error: $X = X^* + \varepsilon$

$$\beta = \frac{\text{Cov}(Y, X^* + \varepsilon)}{\text{Var}(X^* + \varepsilon)} = \frac{\text{Cov}(Y, X^*)}{\text{Var}(X^*) + \text{Var}(\varepsilon)}$$

Whereas the true $\beta^* = \frac{\text{Cov}(Y, X^*)}{\text{Var}(X^*)}$

Hence, the calculated Beta is a biased and inconsistent estimator of the true Beta. This comes about because the X variable is not independent of the error term.

**Two Stage Least Squares, Instrumental variable (IV)** The standard solution to the errors in variable problem is to use an instrumental variable (IV) $z$, which is (1) not correlated with the error term $\varepsilon$ (i.e., exogenous) and (2) is relevant to $X^*$ (i.e., non-zero correlation).

The IV estimator is:

$$\beta = \frac{\text{Cov}(Y, Z)}{\text{Cov}(X, Z)}$$

We can think of this as a two stage procedure.

**Stage 1:** Run the regression $X = a + bz \Rightarrow b = \frac{\text{Cov}(X, z)}{\text{Var}(z)}$

Now define the instrument to be: $\hat{X} = a + bz$

**Stage 2:** Run the regression $Y = \alpha + \beta \hat{X}$

This implies that

$$\Rightarrow \beta = \frac{\text{Cov}(Y, \hat{X})}{\text{Var}(\hat{X})} = \frac{\text{Cov}(Y, a + bz)}{\text{Var}(a + bz)} = \frac{b \text{Cov}(Y, z)}{b^2 \text{Var}(z)} = \frac{\text{Cov}(Y, z)}{b \text{Var}(z)}$$

Now substitute: $b = \frac{\text{Cov}(X, z)}{\text{Var}(z)}$ from the first stage regression and we have that

$$\Rightarrow \beta = \frac{\text{Cov}(Y, z)}{\text{Cov}(X, z) \text{Var}(z)} = \frac{\text{Cov}(Y, z)}{\text{Cov}(X, z) \text{Var}(z)}$$

We can see that two stage least squares gives us the familiar measurement error IV estimator.
Now we will show how 2SLS and IV estimators can be thought of in a general GMM framework. Think of the normal equations of OLS (equations (1) and (2) above)

\[
\begin{align*}
E(Y - \alpha - \beta X) &= 0 \\
E(Y - \alpha - \beta X)X &= 0
\end{align*}
\]

Solving for $\beta$ we obtain

\[
\beta = \frac{\text{Cov}(Y, X)}{\text{Var}(X)}
\]

If we replace $X$ with $z$ in the 2nd equation

\[
\begin{align*}
E(Y - \alpha - \beta X) &= 0 \\
E(Y - \alpha - \beta X)z &= 0
\end{align*}
\]

This implies that $\beta = \frac{\text{Cov}(Y, z)}{\text{Var}(X, z)}$ the instrumental variable estimator. We will show how the GMM moment conditions based on the normal equations of OLS i.e., equation (1) and (2), will nest all of the endogeneity estimators.

The GMM moment conditions based on the normal equations of OLS gives us another way to think of the IV estimator. Take the following example

The simultaneous equations are:

\[
\begin{align*}
Y_1 &= \alpha_0 + \alpha_1 Y_2 + \alpha_2 X_1 + \mu_1 \\
Y_2 &= \beta_0 + \beta_1 Y_1 + \beta_2 X_2 + \mu_2
\end{align*}
\]

Where the $Y$’s are endogenous variables and the $X$’s are exogenous variables. The problem is similar to the measurement error issue i.e., where $Y$ is correlated with $\mu$. This can be seen from equation (4) where $Y_2$ contains the error term $\mu_2$, which then induces in equation (3) a problem similar to measurement error and with similar consequences i.e., biased and inconsistent estimators.

Now consider estimating (3) with 2SLS

(1) **1st stage**: Regress $Y_2$ on the exogenous variables:

\[
Y_2 = \alpha_0 + \alpha_1 X_1 + \alpha_2 X_2 + \varepsilon_2.
\]

Now define the instrument as:

\[
\hat{Y}_2 = \alpha_0 + \alpha_1 X_1 + \alpha_2 X_2
\]

(2) **2nd stage**: In the regression for $Y_1$ use the instrument $\hat{Y}_2$ instead of $Y_2$ as follows:

\[
Y_1 = \alpha_0 + \alpha_1 \hat{Y}_2 + \alpha_2 X_1
\]

Now consider estimating (4) with 2SLS
(1) 1st stage: Regress $Y_1$ on the exogenous variables:

$$Y_1 = b_0 + b_1X_1 + b_2X_2 + \varepsilon_1$$

Now define the instrument as:

$$\hat{Y}_1 = b_0 + b_1X_1 + b_2X_2$$

(2) 2nd stage: In the regression for $Y_2$ use the instrument $\hat{Y}_1$ instead of $Y_1$

$$Y_2 = \beta_0 + \beta_1\hat{Y}_1 + \beta_2X_2$$

The above will give the standard 2SLS estimators. To see how this can be done in GMM consider the following moment conditions. The first three conditions are the normal equations (equation (1) and (2) above) for the $Y_1$ regression, with the first being the condition that the error term is mean zero and the second and third imposing the condition that the error term is uncorrelated with the independent variables. The fourth through sixth moment conditions are the normal equations for the $Y_2$ regression.

$$E \begin{bmatrix} Y_1 - \alpha_0 - \alpha_1 Y_2 - \alpha_2 X_1 \\ (Y_1 - \alpha_0 - \alpha_1 Y_2 - \alpha_2 X_1)(Y_2) \\ (Y_1 - \alpha_0 - \alpha_1 Y_2 - \alpha_2 X_1)X_1 \\ Y_2 - \beta_0 - \beta_1 Y_1 - \beta_2 X_2 \\ (Y_2 - \beta_0 - \beta_1 Y_1 - \beta_2 X_2)(Y_1) \\ (Y_2 - \beta_0 - \beta_1 Y_1 - \beta_2 X_2)X_2 \end{bmatrix} = 0$$

You will notice the endogenous variables are in brackets. To get IV estimators simply replace the endogenous variables $Y_1$ and $Y_2$ with instruments. Here we choose $X_1$ and $X_2$, the exogenous variables in the equation system. This yields the following GMM moment conditions.

$$E \begin{bmatrix} Y_1 - \alpha_0 - \alpha_1 Y_2 - \alpha_2 X \\ (Y_1 - \alpha_0 - \alpha_1 Y_2 - \alpha_2 X)(X_2) \\ (Y_1 - \alpha_0 - \alpha_1 Y_2 - \alpha_2 X_1)X_1 \\ Y_2 - \beta_0 - \beta_1 Y_1 - \beta_2 X_2 \\ (Y_2 - \beta_0 - \beta_1 Y_1 - \beta_2 X_2)(X_1) \\ (Y_2 - \beta_0 - \beta_1 Y_1 - \beta_2 X_2)X_2 \end{bmatrix} = 0$$

2 The GMM moment conditions provide a system approach to testing both equations, thus the unified approach encompasses three stage least squares (3SLS) in addition to 2SLS.
In this way we can see that the system is identified. Textbooks spend many pages on rank and order conditions but basically all you need is to be able to write out the IV system as above and have a unique equation for every parameter.

The following presents an example where there is no identification:

\[ Y_1 = \alpha_0 + \alpha_1 Y_2 + \alpha_2 X_1 \]
\[ Y_2 = \beta_0 + \beta_1 Y_1 + \beta_2 X_1 \]

The normal equations are:

\[
E = \begin{bmatrix}
Y_1 - \alpha_0 - \alpha_1 Y_2 - \alpha_2 X_1 \\
(Y_1 - \alpha_0 - \alpha_1 Y_2 - \alpha_2 X_1)(Y_2) \\
(Y_1 - \alpha_0 - \alpha_1 Y_2 - \alpha_2 X_1)X_1 \\
(Y_2 - \beta_0 - \beta_1 Y_1 - \beta_2 X_1) \\
(Y_2 - \beta_0 - \beta_1 Y_1 - \beta_2 X_1)(Y_1) \\
(Y_2 - \beta_0 - \beta_1 Y_1 - \beta_2 X_1)X_1
\end{bmatrix} = 0
\]

When we go to replace the endogenous variables with instruments we see that we have no more exogenous variables in the system. This leaves two equations that are not separately identified.

\[
E = \begin{bmatrix}
(Y_1 - \alpha_0 + \alpha_1 Y_2 - \alpha_2 X_1) \\
(Y_1 - \alpha_0 + \alpha_1 Y_2 - \alpha_2 X_1)(?) \\
(Y_1 - \alpha_0 + \alpha_1 Y_2 - \alpha_2 X_1)(X_1) \\
(Y_2 - \beta_0 - \beta_1 Y_1 - \beta_2 X_1) \\
(Y_2 - \beta_0 - \beta_1 Y_1 - \beta_2 X_1)(Y_1) \\
(Y_2 - \beta_0 - \beta_1 Y_1 - \beta_2 X_1)(X_1)
\end{bmatrix} = 0
\]

System is not identified as these two equations do not have an instrument.

**Differenced General method of Moments (GMM)** Graham (1996) was the first to apply dynamic models to issues in corporate finance. He looked at the difference in leverage as the dependent variable and the marginal tax rate as the independent variable. The logical extension is to look at the whole equation in changes and add a lagged Y variable to take account of the dynamics of the relationship.

\[ Y_{1t} = \alpha_0 + \alpha_1 Y_{1t-1} + \alpha_2 Y_{2t} + \alpha_3 X_{1t} + \mu_{1t} \]  
(5)

Taking the first difference of equation (5)

\[ Y_{1t-1} = \alpha_0 + \alpha_1 Y_{1t-2} + \alpha_2 Y_{2t-1} + \alpha_3 X_{1t-1} + \mu_{1t-1} \]  
(6)
That is, equation (5) minus equation (6) gives:

\[ \Delta Y_{1t} = \alpha_1 \Delta Y_{1t-1} + \alpha_2 \Delta Y_{2t} + \alpha_3 \Delta X_{1t} + \Delta \mu_{1t} \]

Note that the intercept term cancels and also that the error term will now be correlated.

The estimated moment conditions for this differenced GMM approach are:

\[
E \left[ \begin{array}{c}
\Delta Y_t - \alpha_1 \Delta Y_{t-1} - \alpha_2 \Delta Y_{2t} - \alpha_3 \Delta X_{1t} \\
( \Delta Y_{it} - \alpha_2 \Delta Y_{i(t-1)} - \alpha_3 \Delta X_{it} ) Y_{2t-2} \\
( \Delta Y_{it} - \alpha_2 \Delta Y_{i(t-1)} - \alpha_3 \Delta X_{it} ) X_{i(t-2)}
\end{array} \right] = 0
\]

The instruments are at t-2 as the change in the X variables is from t-1 to t.

**System GMM** The above treats all of the explanatory variables as endogenous and is known as Differenced GMM. It can be run in STATA as a Dynamic Panel. STATA also lets you run System GMM, which is the equation in difference form, instrumented in lagged levels and the equations in levels, instrumented with lagged differences. The level equations would accordingly appear as follows:

\[
E \left[ \begin{array}{c}
Y_t - \alpha_1 Y_{t-1} - \alpha_2 Y_{2t} - \alpha_3 X_{it} \\
( Y_{it} - \alpha_2 Y_{i(t-1)} - \alpha_3 X_{it} ) \Delta Y_{2t-2} \\
( Y_{it} - \alpha_2 Y_{i(t-1)} - \alpha_3 X_{it} ) \Delta X_{i(t-2)}
\end{array} \right] = 0
\]

The above are known as Arellano and Bond estimators. Stephen Bond has an excellent site (www.nuffield.ox.ac.uk/users/bond) on the use of Differenced GMM and System GMM. An excellent example of the application in corporate governance is Wintoki et al. (2012). Of course in the GMM approach you can run your own GMM program and use whatever instruments you like. It is not necessary to use the lagged values that STATA employs.

**Specification tests** There are several important specification tests that are related to endogeneity. Here we cover three of the most important. First, a test for whether endogeneity is indeed a concern for your research i.e., the Hausman Wu test for endogeneity. The second and third specification tests deal with how good your instruments are. The second test examines whether your instrument is correlated with your endogenous variable and the third specification test examines whether your instrument is uncorrelated with the error.

**Testing for endogeneity: the Hausman-Wu test**
The Hausman-Wu test of endogeneity is as follows:

Test: \( H_0: \beta_{OLS} \) is efficient and consistent and
\( H_1: \beta_{IV} \) is consistent.

This hypothesis is tested by the following statistics, which has a \( \chi^2 \) distribution with degrees of freedom equal to the number of elements in \( \beta \):

\[
(\beta_{OLS} - \beta_{IV})^T [V_{IV} - V_{OLS}]^{-1} (\beta_{OLS} - \beta_{IV}) \sim \chi^2_{\#\text{elements}}
\]

The variance in the above test is a point of interest. One would think that the variance of \( \beta_{OLS} - \beta_{IV} \) would be the normal expression for variance including covariance terms:

\[
\text{Var}(\beta_{OLS} - \beta_{IV}) = V_{OLS} - 2\text{Cov}(\beta_{OLS}, \beta_{IV}) + V_{IV}
\]

And it is. However, because OLS is a maximum likelihood estimator it is an efficient estimator meaning that it has minimum variance. We know from Markowitz’s mean variance frontier analysis that the covariance of the minimum variance portfolio with any other portfolio is the variance of the minimum variance portfolio and the same rule applies for efficient estimators. So here the \( \text{Cov}(\beta_{OLS}, \beta_{IV}) \) term equals \( V_{OLS} \) as the OLS estimator has the minimum variance property. The resulting cancellations lead to \( \text{Var}(\beta_{OLS} - \beta_{IV}) = V_{IV} - V_{OLS} \).

**Testing that Instruments are correlated with endogenous variables: F test**

To verify that the instruments that you employ are valid you conduct an F test as follows.

Perform 1st stage regression of the endogenous variable on the instruments:

\[
Y_1 = b_0 + b_1X_1 + b_2X_2 + \epsilon_1
\]

Check the \( R^2 \) and F statistic of the regression. The rule of thumb is \( F>10 \) (Staiger & Stock, 1997). More formal tests are given in Stock and Yogo (2002) and Kleibergen and Paap (2006).

**Testing that instruments are uncorrelated with the error term: Hansen’s over identifying Chi-squared test**

The over identifying J test is a Chi-squared test of whether the instruments are uncorrelated with the error. Many textbook solutions use lagged values of the variables as the identifying instruments.
In using IVs the researcher must first identify a suitable instrument. Using economically meaningful instruments is the best way to go but it is much more difficult than using lagged values of the variables in the system. Such instruments as well as being economically meaningful, should be correlated with the endogenous predictor variable but uncorrelated with the error term. The researcher should provide justification for the use of any particular instrument (Larcker & Rusticus, 2010). In investigating potential and valid instruments, Roberts and Whited (2011) suggest asking the question: “Does the instrument affect the outcome only via its effect on the endogenous regressor?” (p. 27). Researchers in finance and accounting have used a variety of creative instruments. Some examples used in the finance, accounting and economics literature are shown in Table 2.

<table>
<thead>
<tr>
<th>Study</th>
<th>Focus</th>
<th>Instrumental variable</th>
</tr>
</thead>
<tbody>
<tr>
<td>Angrist (1990)</td>
<td>Future earnings prospects</td>
<td>Vietnam war random lottery draw</td>
</tr>
<tr>
<td>Molina (2005)</td>
<td>Leverage and default probability</td>
<td>Marginal tax rate</td>
</tr>
<tr>
<td>Bennedsen, Nielsen &amp; Perez-Gonzalez and Wolfenzon (2006)</td>
<td>Family succession and firm value</td>
<td>Education</td>
</tr>
<tr>
<td>Bennedsen, Kongsted &amp; Neilsen (2008)</td>
<td>Board size on the performance of small to medium firms</td>
<td>Number of children of the chief executive officer</td>
</tr>
<tr>
<td>Bouwman (2013)</td>
<td>Executive Compensation</td>
<td></td>
</tr>
<tr>
<td>King, T., and Williams, J (2013)</td>
<td>Executive compensation</td>
<td>Local sports star salaries</td>
</tr>
</tbody>
</table>

There are many instrumental variables available—perhaps limited only by the researchers’ imagination. Other creative instruments could be: local sports stars salaries as an IV for CEO salaries; women on local councils as an IV for women on corporate boards. However, there are limitations to using IV’s such as refocusing the argument away from the presence of endogeneity to the appropriateness of the IV chosen (Brown et al., 2011).

Again referring to the 24 papers cited in Table 1, only two of the papers conduct the three specification tests and the most common method is 2SLS with only one natural experiment as the research design.

**Endogeneity in finance and accounting**
Much of the empirical corporate governance literature lacks formal theory (Hermalin & Weisbach, 2003) and there is little consensus in this literature on issues relating to performance and governance (Schultz, Tan, & Walsh, 2010). Yet, corporate governance studies, of which there are many, showing a relationship between corporate governance and firm value, have impacted policy. For example, policy relating to Board composition and executive compensation included in SOX. Are such regulations justified in terms of the costs imposed on firms who have to adjust governance structures to be in compliance? Krishnan, Rama and Zhang (2014) estimates $1.4 trillion has been spent on compliance with SOX. This translates to an average firm compliance cost of over $3m (Financial Executives Institute, 2007) and reflects the high cost of restructuring corporate governance mechanisms, which involves the formation of committees and hiring of additional directors. Such costs may well be justified if we had compelling causal evidence to support legislated governance restructuring.

Many studies show corporate governance structure to be a largely endogenous characteristic of the firm (Coles, Lemmon, & Felix, 2012; Demsetz, 1983; Demsetz & Lehn, 1985; Hermalin & Weisbach, 2003; Wintoki et al., 2012). So for the vast number of corporate governance studies showing a relation between governance and performance, even if rigorously designed, it is safe to say they are fraught with issues of endogeneity i.e., the optimal level of corporate governance is endogenously determined at the firm level (Demsetz, 1983). So if firms are at an internal equilibrium, then a forced change in governance structure may be detrimental to firm performance as sub-optimal governance structures may reduce performance. Schultz, Tan and Walsh (2010) use a dynamic generalized method of moments (GMM) specification ‘robust to all forms of endogeneity’ to evaluate the governance/performance relationship. In doing so, they aim to address the lack of consensus in the literature regarding the relationship. Not surprisingly, they find no significant relationship between firm value and governance. This is contrary to the many studies using pooled ordinary least squares (OLS) and fixed-effects models. Schultz et al. conclude these latter studies are subject to spurious correlations.

Arguably, it is much better to model the ownership/performance relation at the firm level e.g., model the pay/performance relation at the firm level and observe the pay-performance sensitivity that maximizes performance. Coles, et al. (2012) model the relationship at the firm level by looking at the productivity parameters for managerial input and investment that would give rise to the observed level of ownership and investment. Their results seem intuitive. They find the productivity of managerial input is high in personal and business services and equipment industries such as education, software,

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3 Sarbanes-Oxley Act of 2002 set new standards for corporate governance including number of independent directors.
networking and computers. They also find the productivity of managerial input is low in metal mining and utilities. Also they model Tobin Q values and find they are highly correlated with observed Q.

**Graphic example of the detrimental effects of mandating insider ownership**

If firms are at an internal equilibrium, then a forced change in governance structure will not improve firm performance. In fact not only is restructuring costly to implement but it may be directly detrimental to firm performance. This is because the optimal level of ownership is endogenously determined at the firm level (Demsetz, 1983). Figure 1 graphically illustrates the cost to firms when forced to adopt a sub-optimal ownership structure and a similar illustration appears in Larcker and Rusticus (2007). In Panel A, each firm internally optimizes their insider ownership/performance relationship. For firm A that is 3%, for firm B it is 7% and for firm C it is 5%.

Assume now a senate committee commissions a study to examine the corporate governance and performance relation. Based on this study all firms are required (forced by regulation) to adopt the “optimal level” of insider ownership. In Panel B, 5% ownership is considered the optimal ownership level. Firm A has been forced to increase its board size beyond its optimal 3%. Firm B is forced to reduce its size and is also no longer at its optimal level. Only Firm C is at its optimal structure post regulation. We can see from Panel C the loss in performance to A and B if they have 5% ownership. In contrast an instrumental variables estimation approach tends to find no relationship. This is illustrated in Panel D of Figure 1. So if the optimal level of ownership is endogenously determined at the firm level i.e., ‘the value maximizing governance choices of one firm may be very different to the value maximizing governance choices of another firm’ (Demsetz, 1983); then if firms are at an internal equilibrium a forced change in governance structure will not improve firm performance. In fact, it may be detrimental to firm performance. Policy prescriptions based on conflicting research will inevitably prove suboptimal in many cases. Developing better theory and more compelling evidence to fully describe the relationship between insider ownership and performance is accordingly part of the solution and this is where natural experiments can be valuable.

**Natural experiments: state-of-the-art solutions to endogeneity**

A natural experiment can be one of two things: (1) a randomized trial set up by the researcher in a natural setting4 or; (2) a naturally occurring state (event) resulting from a social or political situation and thus not intentionally set up by the researcher. Well-designed research incorporating either of these types of experiments aims to isolate and strengthen causal inference and thus build better

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4 This excludes experiments in a laboratory or other artificial environments
theories. If well executed, i.e., using a convincingly exogenous event, then both provide compelling evidence because the issue of endogeneity is not a concern.

A randomized trial in a natural setting is set up and controlled by the researcher. Economists regularly use randomized trials to study a multitude of issues. These studies are designed to measure outcomes based on observations of a treatment group and a control (or comparison) group that have been randomly assigned. If implemented correctly the researcher creates two (or more) groups that are on average probabilistically similar so that any observed differences are due to the treatment and not to other differences in the groups (Shadish, Cook, & Campbell, 2002). Angrist and Pischke (2010) detail some influential randomized experiments in economics, e.g., the ‘Moving to Opportunity’ program; or the Progresa program in Mexico etc. The advantage of randomized trials is that when the research design is robust, such experiments provide convincing evidence. However, randomized trials come with a multitude of practical difficulties, not least of which are randomizing group assignment, ethical issues in dealing with human subjects, as well as gaining access to subjects. Such trials are also expensive and time consuming to implement. In finance, randomized experiments are difficult to implement. For example, it is not feasible to conduct randomized trials of bank failures, corporate governance changes, or tax changes. Thus there are relatively few examples of randomized trials in a natural setting in the finance literature. Two notable studies are Choi, Laibson and Madrian (2010) and Kaplan et al. (2013). Choi and Laibson, investigate the fee structures of mutual funds and why individuals invest in high-fee index funds. The authors set up an experiment where subjects were given a hypothetical $10,000 to invest and randomly assigned to receive varying levels of information about four S&P 500 index funds. The experiment showed investors routinely fail to minimize fund fees. A common criticism of such experiments is that we do not know if the results hold in real situations i.e., incentives and attitudes to risk are likely to change when investors are actually using their own funds. Kaplan et al. (2013) examine the impact of short selling in stock markets. Specifically, they investigate whether short selling makes markets more efficient by improving price discovery, or if short selling distort markets and adversely affects prices. The authors, with the cooperation of a large money manager, randomly

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5 This program randomly selected low-income families in Baltimore, Boston, Chicago, Los Angeles, and New York City to be offered housing vouchers specifically limited to low-poverty areas (Kling, Liebman, and Katz, 2007 as cited in Angrist & Pischke, 2010). The idea of the program was to determine if neighborhood effects are a primary determinant of low earnings by the residents of poor neighborhoods (p. 4).

6 The Progresa program in Mexico offered cash transfers to randomly selected mothers, contingent on participation in prenatal care, nutritional monitoring of children, and the children’s regular school attendance. As a direct consequence of this program thirty countries worldwide have conditional cash transfer programs. Further the results of this program have influenced the move to random assignment policy evaluations in development economics (p. 3)
made available or withheld stocks from the lending market. Whilst such experiments provide novel results they require cooperation of practitioners and investors and such cooperation may be difficult to attain.

It is the second type of natural experiment, a naturally occurring state or event, which provides more opportunities for finance and accounting researchers. A *naturally occurring state*, often comes about from a social or political situation (Dunning, 2007) such as a government policy change. Natural experiments are not ‘true’ experiments and are sometimes referred to as ‘quasi’ experiments (Meyer, 1995). This is because the so called *naturally occurring state* is not intentionally set up by the researcher and so the treatment group is not randomly assigned. Such experiments are more like observational studies where the researcher cannot manipulate the environment, although; the researcher must choose the comparison or control group. In these types of research design, control groups and treatment groups may differ in systematic ways other than in regard to the treatment. The researcher therefore has to be concerned about ruling out such effects.

Some examples of naturally occurring events of interest to finance and accounting researchers may include: legislated corporate governance changes (e.g., SOX); or tax changes across jurisdictions that can justifiably be seen as exogenous sources of variation in the explanatory variables of interest. Meyer (1995) gives the example of the Vietnam era draft mechanism, which depended on date of birth, as an exogenous event to study the effects of military service on earnings. Research utilizing natural experiments is growing in the fields of economics (Dunning, 2007), although; not very common in finance and accounting.

Finance and accounting researchers may see an obvious roadblock to designing research around a natural event. That is: how often will issues yield themselves to the kind of actual randomization that and Ljungqvist (2014) for example exploit? Researchers though, may not be aware of the number of situations or naturally occurring events that could be used in natural experimental research and thus many more natural experiments may be available than researchers realize. Generally studies making use of natural experiments are motivated by existing evidence and thus address issues fundamental to a discipline. Table 3 provides a sample of finance and accounting research that utilizes natural experiments. All address issues fundamental in the disciplines. Using such events as exogenous factors in a model helps researchers to provide a constructive link between the real world and econometric methodology (Angrist & Pischke, 2010).
Table 3: Recent research in Finance and Accounting utilizing natural experiments

<table>
<thead>
<tr>
<th>Study</th>
<th>Focus</th>
<th>Source of natural experiment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Haselmann, Pistor and Vig (2010)</td>
<td>Creditor rights and the size of creditor markets</td>
<td>Reforms of creditor rights across 12 transition economies</td>
</tr>
<tr>
<td>Kisgen and Strahan (2010)</td>
<td>Credit ratings and firms’ cost of capital</td>
<td>Dominion Bond Rating Service (DBRS) becoming a recognized rating agency in 2003</td>
</tr>
<tr>
<td>Iyer and Peydro (2011)</td>
<td>Financial contagion due to interbank linkages</td>
<td>Large bank failure outside of financial crisis</td>
</tr>
<tr>
<td>Nguyen and Nielsen</td>
<td>Corporate governance and firm value</td>
<td>Sudden death of CEO</td>
</tr>
<tr>
<td>Puri et al. (2011)</td>
<td>Credit crises and supply of credit to retail customers</td>
<td>German retail banks pre and post GFC</td>
</tr>
<tr>
<td>Kaplan et al. (2013)</td>
<td>Effects of stock lending on security prices</td>
<td>Randomized stock lending experiment</td>
</tr>
<tr>
<td>Kelly and Ljungqvist (2012)</td>
<td>Information asymmetry and asset prices</td>
<td>Brokerage closures due to: 4429 coverage terminations due to 43 U.S. brokerage firms closing research departments between Q1, 2000 and Q1, 2008 and 356 coverage terminations due to September 11 terrorist attacks</td>
</tr>
<tr>
<td>Gropp, Gruendl and Guettler (2014)</td>
<td>Public guarantees on bank risk-taking</td>
<td>EU court ruling to remove government guarantee for savings banks</td>
</tr>
<tr>
<td>Gormley, Matsa and Milbourn (2013)</td>
<td>CEO compensation and corporate left-tail risk</td>
<td>Workplace exposures to carcinogens and newly classified carcinogens</td>
</tr>
</tbody>
</table>

Note: This table is not exhaustive and is intended to provide the reader with examples of the types of events used as natural experiments in recent finance and accounting research.

Quasi natural experiments have some advantages over randomized trials. First, they minimize ethical dilemmas involved in using human subjects. They also minimize problems that can be attributed to the researchers’ influence when setting up a randomized trial stemming from the researchers’ interaction with participants e.g., paternalism, inequity, and deception—even though these things are not intentional, they are difficult to completely avoid. Additionally, natural experiments remove the problem of access to practitioners, which can be a particular problem in financial markets, and generally they are useful when random assignment is neither possible nor ethical.

The inferences drawn from natural experiments are often criticized as being limited to a particular time and place. However, this is not necessarily the case. Angrist and Pischke, (2010) cite several
examples where natural experiments have been used to address issues including those that affect the entire world or the march of history. For example, Nunn (2008) uses a wide range of historical evidence, including sailing distances on common trade routes, to estimate the long-term growth effects of the African slave trade. Deschênes & Greenstone (2007) look at random year-to-year fluctuations in temperature to estimate effects of climate change on energy use and mortality. In a study of the effects of foreign aid on growth, Rajan and Subramanian (2008) construct instruments for foreign aid from the historical origins of donor–recipient relations. Natural experiments have also provided the basis for significant policy choices for centuries. Dunning (2007) provides the example of 19th Century London Cholera outbreaks. This and the examples above, speak eloquently for the wide applicability of a natural experiment-design-based approach.

The advantage of using natural experiments, when well considered, is that they are an exogenous event. At least the researcher should convince her audience this is so. Studies using such events make a strong case for a causal interpretation of the results. Meyer (1995) argues their main contribution of such research designs is in providing understanding of the source of the causal relationship. The disadvantage is the time spent collecting data particularly considering there are often a lot of events. Another problem is validating the ‘as if’ random assignment of the comparison and control groups (Dunning, 2007).

**Designing research around a natural experiment**

To lay the foundation or road map for researchers wanting to utilize a natural experiment, we now detail two concrete applications. Both studies, which we offer as exemplars, make use of a natural experiment providing an exogenous source of variation in the main explanatory variable. The first study is Heider and Ljungqvist (2014). These authors exploit jurisdictional variation in tax changes across U.S. States to estimate the tax sensitivity of leverage from exogenous state tax changes. As the authors note, in an ideal world the researcher could set up a truly randomized experiment. In this case that would involve ‘randomly assigning different tax rates to firms and then comparing their debt policies to see if higher tax rates lead to higher leverage. Random assignment would ensure that ‘observed differences in leverage could not be caused by unobserved firm-level heterogeneity’ (Heider & Ljungqvist 2014 p.2). However; we do not face an ideal world and such truly random experiments with a treatment and control group are not possible. The next best method is to seek tax changes that are plausibly exogenous. The second study we offer as an exemplar of utilizing a naturally occurring event is that of Nguyen and Nielsen (2010). Nguyen and Nielsen (2010) use the sudden death of independent directors as an exogenous event impacting firm value. Their focus is the value of independent directors to shareholder value.
To date, the research on these two fundamental issues is plagued by problems of endogeneity including a lack of solid theory. For example, do high-profit firms borrow more because debt offers valuable tax shields or because their marginal cost of debt is lower? The perplexing issue of endogeneity in the corporate governance literature is already discussed above.

**Road map illustrated with two recent studies**

The following steps provide a guide to an ideal approach to this type of research design.

1) *Lay a solid foundation for the research design/methodology.*

As customary desirable for any research design, first outline the current thinking or theory related to the research question and in this case establish the existence of and possible sources of endogeneity. The goal is to substantiate how a natural experiment could overcome such problems. In Heider and Ljungqvist, we know from previous literature that taxes are important in capital structure; but to what degree? The sources of endogeneity noted by the authors include: high profit firms are in higher tax brackets, and such firms may borrow more to take advantage of tax shields, or; high profit firms may borrow more because their default risk is lower. ‘A simple comparison cannot tell if high-profit firms borrow more because debt offers valuable tax shields or because their marginal cost of debt is lower. Unobserved differences across firms would impart a positive bias in the estimated tax benefit’. (p. 3)

In the second study of Nguyen and Nielsen, intuitively researchers know that board composition is determined endogenously e.g., we can argue that poor performance is a result of previous board decisions as well as a factor that influences subsequent appointments of more independent board members. The research thus far provides scant evidence of any cross sectional relationship between firm performance and board composition or the ratio of insiders to outsiders (Hermalin & Weisbach, 2003). Some studies, as reviewed by Hermalin and Weisbach (2003), use lagged performance measures to correct for endogeneity and still find no evidence of a causal relationship between board independence and firm performance. Given recent legislation governing board composition the link between the number of independent directors and firm value is a significant one. The authors accordingly lay the foundation for the research design.

2) *Identify the natural event(s)*

This step determines the treatment group i.e., the group affected by the event. Here it is important to use as many data points as available. Having multiple treatment groups, which may be affected by the event in different time periods, different locales or with different intensities, strengthens the external validity of the results. Heider and Ljungqvist exploit the natural event of staggered changes in U.S. state corporate income tax rates. State tax changes are used in preference to Federal tax changes because state changes occur more frequently and at different times. Their data includes: 38 corporate tax increases in 25 states affecting 1,824 firms over 1990-2011; and 67 corporate tax decreases in 29 states affecting 7,021 firms. Nguyen and Nielsen use sudden death of independent directors identified
from companies listed on Amex, NASDAQ, and NYSE from 1994-2007. They identify 229 (out of 772 director deaths) cases that satisfy the strict definition of sudden death of a director. Of this 229, 108 are identified as independent directors.

3) Verify the natural event is plausibly exogenous.

The researcher is obliged to provide the reader with clearly identified and understood exogenous events and thereby rule out other explanations. This part of the research is critical to the internal validity of the results. As Heider and Ljungqvist note, State tax changes occur for a reason and this could make them endogenous (simultaneously determined) to capital structure. For instance, tax changes could result from economic downturns and firms could borrow more in economic downturns. In this study the authors control for various confounds such as unobserved variation in local business conditions or investment opportunities, union power, and states’ political leanings.

In Nguyen and Nielsen the definition of independence is critical. The authors follow the previous literature and use length of tenure and length of tenure relative to tenure of CEO as two measures of independence. Further, deaths of the independent directors are required to be both sudden and unanticipated by the market to justify these events as random and exogenous to current firm or market conditions. The authors are conservative in trying to exclude any deaths that could have been foreseen by the market e.g., excluding the death of elderly directors, or those with known prolonged illnesses where it is likely the death is anticipated. Also excluded are observations where other confounding news could affect firm value at the time of sudden death. Sudden death also alleviates the argument that appointments of independent directors could be driven by the need for change.

4) Comparison of treatment group pre and post event

As a method of preliminary analysis, the research design may include a simple comparison of the treatment group pre and post event. By itself this is not likely to lead to strong inferences because it is difficult to determine that the treatment group would have been the same over time in the absence of the event. If this is the extent of the research design then the researcher would need to provide strong evidence that the treatment group would have been the same over time in the absence of the event (Meyer 1995). This is essentially the approach taken by Nguyen and Nielsen. They use an event study to look at CAR pre and post event of firms where an independent director has died suddenly.

5) Determine the control or comparison group

The control or comparison group should not be affected by the exogenous change in the explanatory variable. The study is strengthened by identifying a comparison group that is similar to the treatment group in relevant dimensions, however; only randomly different across the variables under study. Heider and Ljungqvist use firms in neighboring states not affected by tax changes e.g., firms in North
Carolina affected by a tax rise are compared to firms in the same industry in the neighboring state of South Carolina. Nguyen and Nielsen identify stock price reactions against director type i.e., inside and gray as well as the independent directors.

6) **Comparison of treatment and control group:**
These groups may be compared using a number of approaches e.g., a difference-in-differences technique or an event study. Heider and Ljungqvist corroborate the exogenous nature of the tax changes by looking at what happens to firms in the same industry in neighbouring States where there are no tax changes. Nguyen and Nielsen use an event study to examine stock returns in the -5 day to +5 day event window coincident with the sudden death of an independent director. The results show pre and post event returns on the overall sample and separately for independent, gray and inside directors.

7) **Control for standard variables found in the literature**
Including control variables is a standard way to allow for observable differences across the treatment and control groups. In this case Heider and Ljungqvist control for standard variables in the debt literature including: profitability (return on assets); firm size (total assets); tangibility (the ratio of fixed to total assets); and investment opportunities (market-to-book). In our second study Nguyen and Nielsen use a multivariate approach to control for director and firm characteristics. Such control variables include: director age, firm size, firm age, market-to-book, and board size. Further, the study applies a fixed effects approach to isolate and control for independent director ability and skill.

8) **Determine if the magnitude of the effects are economically meaningful**
The strength of the results and thus the conclusions regarding economic magnitude are reliant on having ruled out confounding influences. Heider and Ljungqvist include industry-year effects to eliminate time-varying industry shocks. Robustness tests also show the results hold within-firm (ruling out that they are driven by time-invariant firm heterogeneity). Further tests also show the results are robust to the inclusion of state fixed effects and changes in local economic conditions, changes in local labor market conditions, and changes in a state’s political leanings. Nguyen and Nielsen investigate alternative specifications such as ruling out firms that may have been affected by confounding news at the time of the director’s death and ruling out firms where the age of the director may increase the probability of mortality.

9) **Reversal of the initial event**
Findings are strengthened by investigating the effects of a reversal in the treatment (Meyer, 1995). For example, Heider and Ljungqvist look at reversals of tax increases and find leverage increases
permanently. Not all events will lend themselves to reversal. The Nguyen and Nielsen study does not investigate the situation where independent board members are later replaced with inside directors.

The true test of research designs using natural experiments as sources of exogenous variation partly rests with the significance of the results. Heider and Ljungqvist find a positive relation between increases in taxes and leverage i.e., firms increase leverage on average by 114 basis points in response to a rise in their home State taxes. This effect is asymmetric i.e., firms do not decrease their leverage in response to tax cuts. This paper provides compelling evidence that taxes are a first-order determinant of capital structure choices. Importantly, the paper contributes to capital structure theory by providing strong evidence that the tax sensitivity of leverage is asymmetric, which is contrary to current belief.

Nguyen and Nielsen find that stock prices fall by 0.85%, which translates into an average of $35m decrease in firm value as a result of the sudden death of an independent director. The study more specifically shows that the value of an independent director is susceptible to the influence of powerful CEOs and also to the number of independent directors on the board. Further this study shows there is value added if independent board members perform a particular board function such as chairman or member of the audit committee. Previous studies on corporate governance and firm value fail to reach to convincing and meaningful conclusions because corporate governance structure is endogenously determined. This study adds to a deeper understanding of the effects of corporate governance on firm value.

**Limitations of natural (quasi) experiments**

In any research design, researchers need to be aware of issues that undermine the causal inferences. A natural experiment that is plausibly exogenous may diminish problems of omitted variable bias and simultaneity. However, in utilizing natural experiments researchers face other threats to internal and external validity.

*External validity:* Evidence provided by natural experiments are most convincing with more complex research designs e.g., using multiple exogenous changes in corporate governance. Using one event leaves the results open to criticisms that they are local and derived from a particular time and place. The response to this is to look for more evidence. It is possible for example to exploit national or jurisdictional borders since a policy shift on one side of a border may not affect groups on the other side of the border. Jurisdictional boundaries provide the most convenient basis for natural experiments (Dunning, 2007). Using multiple treatment and comparison groups allows further checks on hypotheses and strengthens the validity of the inferences (Meyer, 1995).

*Internal validity:* The researcher must provide a convincing argument that the source of the natural experiment is truly exogenous e.g., that policy changes are not in response to changes in the variables
under study. Also the researcher must perform exhaustive robustness tests to convince the reader of the validity of the results.

**Conclusion**

This paper provided a discussion of endogeneity in finance and accounting empirical research: the problem, its scope, and current textbook solutions. We note that endogeneity is increasingly seen as a concern and it is insufficient for researchers to label some variables endogenous and others exogenous without providing strong ‘institutional or empirical support for these identifying assumptions’ (Angrist & Pischke, 2010). We provide a road map for research design using a-state-of-the-art solution-a natural experiment. Researchers can utilize such experiments to mitigate the problem of endogeneity and in doing so build better theory to justify their model. This technique involves using naturally occurring exogenous events.

However, there are two caveats. First, not all regulation or policy changes are sources of exogenous variation. Calling a policy change a natural experiment does not make it an exogenous source of variation (Meyers, 1995). Second, researchers, in looking for and using natural experimental events, should retain a clear focus on research design to improve empirical work and avoid seeking good answers over good questions. There is a chance that researchers will look for good experiments regardless of the importance of the questions they ask. The positives is that well designed studies around natural experiments will progress theory and thus these types of studies will get the most weight in the compiling of evidence, while other evidence, which we know is subject to issues of endogeneity, is likely to be treated as more provisional (Angrist & Pischke, 2010).

**References**


Figure 1 Optimal insider ownership/performance relation

Panel A: Each firm internally optimizes the insider ownership/performance relationship

Panel B: Level of insider ownership mandated at 5%

Panel C: Loss of performance due to mandated ownership level

Panel D: IV Estimation finds no relation between insider ownership and performance

Arrows show loss of performance from mandated ownership levels
<table>
<thead>
<tr>
<th>Author/Year</th>
<th>Endogeneity Issue</th>
<th>Specification Tests(1), (2), (3)</th>
<th>Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hoang, Faff &amp; Haq (2010)</td>
<td>Endogenous explanatory variables: market discipline, bank capital and charter value to explain Bank risks</td>
<td>(1), (2), (3)</td>
<td>Two-step system GMM</td>
</tr>
<tr>
<td>Koerniadi, Krishnamurti, &amp; Tourani-Rad (2014)</td>
<td>Return volatility and corporate governance variables, e.g., board size, block holding.</td>
<td>(1) (No endogeneity found);</td>
<td>Pooled OLS regression, fixed effects, and GMM: control for 3 types of endogeneity: dynamic, simultaneity and unobserved heterogeneity.</td>
</tr>
<tr>
<td>Arqawi, Bertin, &amp; Prather (2013)</td>
<td>The relationship between leverage and warranty provisions: e.g., unobservable characteristics of a manager who makes both decisions (simultaneity)</td>
<td>(1), (No endogeneity found)</td>
<td>GLS Panel regression</td>
</tr>
<tr>
<td>Xu, Liu, &amp; Huang (2013)</td>
<td>Cost of capital effects of CSR may be driven by omitted variables that are correlated with both CSR and the cost of equity capital (corporate governance)</td>
<td></td>
<td>2SLS (IV)</td>
</tr>
<tr>
<td>Choe, Dey, &amp; Mishra (2013)</td>
<td>Diversification decisions and firm performance; and self-selection issue of diversification choices</td>
<td></td>
<td>Lewbel’s (2012) instrumental variable estimation, Heckman's 2-stage model</td>
</tr>
<tr>
<td>Khan, Mather, &amp; Balachandran (2012)</td>
<td>Managerial ownership and performance and investment</td>
<td>(1)</td>
<td>Simultaneous equation 3SLS (IV)</td>
</tr>
<tr>
<td>Tan &amp; Cam (2002)</td>
<td>Independent trustees may endogenously restrict their voice because they rely on other trustees for nomination and election.</td>
<td></td>
<td>Cross-sectional regression (fund costs and governance)</td>
</tr>
<tr>
<td>Amir, Kallunki, &amp; Nilsson (2014)</td>
<td>Stock returns to earnings per share (scaled by stock price, as the dependent variable)</td>
<td></td>
<td>Firm fixed-effects panel regression model</td>
</tr>
<tr>
<td>Dichev &amp; Li (2013)</td>
<td>Growth rate in PPE and accounting choices (e.g., lease, depreciation life decisions) at the cross-sectional level.</td>
<td></td>
<td>Use changes in growth rates rather than levels using Fama-MacBeth regression with Newey-West adjusted standard errors</td>
</tr>
<tr>
<td>Chu, Liu, &amp; Tian (2014)</td>
<td>Control-ownership divergence and stock liquidity: (omitted variable problem)</td>
<td></td>
<td>Use a natural experiment of the Non-tradable share reform</td>
</tr>
<tr>
<td>Authors</td>
<td>Specification tests</td>
<td>Ref.</td>
<td>Notes</td>
</tr>
<tr>
<td>-------------------------</td>
<td>--------------------------------------------------------------------------------------</td>
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<td>-------------------------------------------------</td>
</tr>
<tr>
<td>Magee (2013)</td>
<td>Ratios of total FX derivatives to assets and total liabilities to assets</td>
<td>(1), (2), (3)</td>
<td>2SLS, GMM IV</td>
</tr>
<tr>
<td>Chiang, Chung, &amp; Huang (2013)</td>
<td>Ownership structures, board characteristics and default risks.</td>
<td></td>
<td>Dynamic GMM</td>
</tr>
<tr>
<td>D'Espallier, Huybrechts, &amp; Schoubben (2013)</td>
<td>Cash flow resulting from potential correlation between cash flow and the idiosyncratic component of the error</td>
<td>(2)</td>
<td>System GMM</td>
</tr>
<tr>
<td>Al-Maskati, Bate, &amp; Bhabra (2014)</td>
<td>Diversification decision and choice of governance structure</td>
<td>(3)</td>
<td>GMM</td>
</tr>
<tr>
<td>Choi and Lee (2014)</td>
<td>Choice of (high-quality) auditors is not random</td>
<td>(3)</td>
<td>Heckman's 2 stage self-selection model</td>
</tr>
<tr>
<td>Fargher, Jiang, and Yu (2013)</td>
<td>CEO equity wealth and audit fees jointly determine firm risks.</td>
<td>(1)</td>
<td>2SLS</td>
</tr>
<tr>
<td>Martínez-Sola, García-Teruel, and Martínez-Solano (2013)</td>
<td>Trade credit decisions (e.g., high level of sales would lead to higher profits and also to more trade credit given.)</td>
<td>(3)</td>
<td>GMM</td>
</tr>
<tr>
<td>Sultana, Mitchell, and Zahn (2013)</td>
<td>Governance variables and other contracting mechanisms.</td>
<td></td>
<td>2SLS</td>
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<tr>
<td>Steijvers and Niskanen (2013)</td>
<td>Leverage and cash ratios.</td>
<td>(1)</td>
<td>2SLS (IV)</td>
</tr>
<tr>
<td>Hutchinson, Mack, and Plastow (2014)</td>
<td>Board gender diversity and the nomination committee gender diversity.</td>
<td></td>
<td>2SLS, 3SLS, Heckman's two-stage selection model</td>
</tr>
<tr>
<td>Choi, Kwak, Choe (2014)</td>
<td>CEO turnover and corporate performance; potential selection bias that a firm's CEO turnover decision is not random</td>
<td></td>
<td>2SLS, Heckman's 2-stage model</td>
</tr>
<tr>
<td>Kouwenberg and Phunnarungsri (2013)</td>
<td>Corporate governance and firm value</td>
<td></td>
<td>Regression analysis on the market reaction (CAAR) to announcements of violations of listing rules by SET and SEC.</td>
</tr>
<tr>
<td>Cho and Lee (2013)</td>
<td>R&amp;D investment and the degree of IPO underpricing.</td>
<td></td>
<td>2SLS</td>
</tr>
</tbody>
</table>

Note: Specification tests: (1) the Hausman-Wu endogeneity test; (2) F-test; (3) Hansen’s over identifying Chi-squared test.