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# **The Mediating Role of Cash Slack in the Related Variety and Sales Growth Relationship: Evidence from Norway**

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## **Abstract**

The purpose of this paper is to uncover how related variety influences firm sales growth through firms' cash slack. We apply a causal steps approach and causal mediation analysis to 100,371 observations covering 16 Norwegian municipalities. We find that cash slack plays as a positive mediating role, and the regression results are robust. Our study expands both related variety studies by providing a theoretical micro-level foundation, and firm growth theory by showing that cash slack is a concrete mechanism connecting external industrial environment and firm growth.

Key words: related variety, sales growth, cash slack, mediation effect, Norway

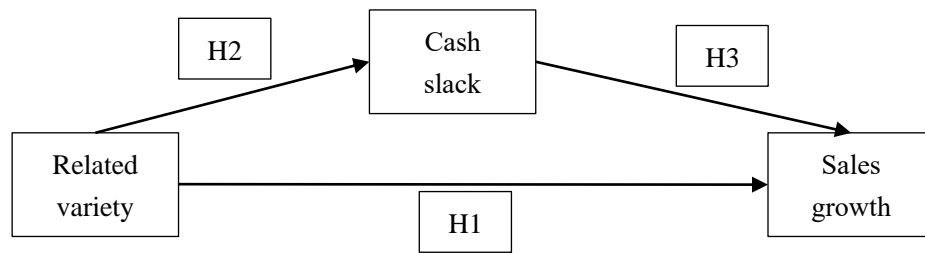
## 1. Introduction

Industrial variety has received increasing research attention from both regional economists and economic geographers (Boschma et al., 2012; Moraes & Luna, 2018; Oort et al., 2015). Since Frenken et al. (2007) published their seminar paper that deepened Jacobs' (1969) externality argument, many studies have shown that related variety influences economic performance: for example, related variety influences industrial innovation (Erkus-Ozturk, 2017), regional labor markets (Aarstad & Kvitastein, 2019), economic policy (Asheim et al., 2011), and economic growth (Fritsch & Kublina, 2018). As Kanó et al. (2019, p.2101) summarized; "related variety of economic activities in a region is crucial for economic performance ... (and) a vast body of empirical results supports these claims."

Since related variety is used to describe regional industrial structure, most studies in this research field have concentrated on regional level issues (Firgo & Mayerhofer, 2018; Silva et al., 2019). **This leaves a research gap: the industrial variety perspective lacks theoretical micro-foundation** (Content & Frenken, 2016). That is to say, industrial variety studies lack insights from the viewpoint of firms. On one hand, not many studies in this research field explore how related variety influences firms and how firms change related variety (Ibid). On the other hand, in the few studies that departed from the firm level, typically set related variety as independent variable and firm performance as dependent variable, showing for instance how related variety directly influences firms' productivity (Aarstad et al., 2016), firms' patents (Castaldi et al., 2015), firms' absorptive capacity (Fritsch & Kublina, 2018), and firms' survival (Howell et al., 2016). Such studies consider related variety as an environmental variable and firm performance as primarily influenced by internal factors (Hoskisson et al., 2018). Thus, Frenken et al.'s related variety perspective lacks arguments that uncovers the mechanisms that link external environment (i.e., related variety) with firm performance.

In this paper, we attempt to fill this gap by examining a concrete linking mechanism: **How related variety influences firms' sales growth through changing firms' cash slack**. Cash slack or excess liquidity gives firms competitive resources and reduces firms' risks. Sales growth is an ideal dependent variable. Sales growth motivates firm behavior and is a good measure of competitive success. On one hand, sales growth reflects that firms' products and services have sufficient market demand and satisfy customers' preferences (Coad et al., 2013). On the other hand, sales growth provides the 'top line' of the business, and thus the foundation for business profit, or 'bottom line' as business people would call it. Sufficient profits allow firms to conduct innovations (MacDonald, 1997), strategic investment (Lau, 2011) and human resource cultivation (Chandler et al., 2009). We choose cash slack as the mediator, because it is a factor directly influenced by external environment (Vanacker et al., 2013); meanwhile cash slack as a type of resource can be used to execute firm strategies for achieving the firm's sales growth (Boso et al., 2017; Geiger & Cashen, 2002; Geiger & Makri, 2006; Tan & Peng, 2003). Therefore, cash slack provides a mediating mechanism, uncovering the relationship between related variety and sales growth. Figure 1 visualizes the conceptual model of this paper.

Figure 1: The Conceptual Model



By filling in the research gap mentioned above, our paper responds to Content and Frenken’s (2016) call, which noted that studying related variety with the viewpoint of firms is a grand challenge in Frenken et al.’s related variety perspective. Our paper expands Frenken et al.’s perspective by contributing insights from firm-level performance (i.e., sales growth). Considering that sales growth as a variable that reflects firm performance could be influenced by many factors (Distante et al., 2018; Joseph & Wilson, 2018; Spescha & Worter, 2019), we further uncover that cash slack as a firm resource could be a mechanism that connects related variety with sales growth. In other words, we intend to test cash slack as a concrete mechanism mediating “external environment - firm resource - firm performance”. Our paper also contributes to practitioners in terms of how to make location decision to make growth and how to utilize location environment to generate cash slack that serves growth. Our paper may also assist policy makers who make regionally industrial developing plans.

This paper is organized as follows: section two introduces relevant knowledge and develops research hypotheses. Section three presents methodology, including data collection and regression models. Section four shows regression results as well as robustness tests. The last section concludes and summarizes

## 2. Theoretical Background and Hypotheses Development

This section contains two parts. Part one introduces two basic concepts, namely related variety and cash slack. Part two advances three hypotheses for showing how cash slack resource mediates “related variety – sales growth” relationship.

### 2.1 Concepts

#### I. Related Variety

Related variety is coined by Frenken et al. (2007) for extending Jane Jacobs’ (1969) externality viewpoint. Related variety is defined as “regional industry structure having complementary and overlapping knowledge base” (Aarstad et al., 2019, p.781). This definition is somehow abstract. We provide more details below.

Related variety has two features. First, related variety is a concept that describes a specific regional industrial structure. Therefore, related variety is closely linked to geography. Particularly, related variety mainly describes the industrial structure of a certain region, such as city, province, state, or country (Antonietti & Gambarotto, 2020; Van Oort et al., 2015). Rare studies applied related variety at rural level or national level, since the former is normally dominated by agriculture; and the latter could be too large in terms of territory, and applying related variety then makes no sense.

Furthermore, since related variety has geographic attributes, it implies that a region's related variety in a given time period is fixed.

Second, the level of related variety is based on the industrial classification system. Related variety reflects that a region can have several 2-digit level industries (hereafter industries for short) and 4-digit level sectors (hereafter, sectors for short) at the same time. Take North American Industrial Classification System (NAICS) as an example, related variety describes the number of four-digit sectors under the same two-digit industry, and how four-digit sectors differ in terms of size. A low level of related variety implies that a region has the small number of sectors under the same industry and that the size of them varies considerably. Conversely, it implies that there is the large number of sectors in the same industry and that sectors are more balanced in size.

For easy understanding, we provide a concrete example for showing what related variety is: assume that a region contains a two-digit industry, namely textile industry. If the textile industry contains a lot of four-digit sectors, such as cotton, silk, wool, velvet sectors, etc., related variety is high; alternatively, if the cotton, silk, wool, velvet sectors develop evenly, related variety is high. However, when the textile industry only contains few sectors (e.g., only contains cotton sector), or some sectors are very large but others are small, related variety is low.

## II. Cash slack

Cash slack refers to liquid funds in excess of firms's daily operational needs and indicates the level of liquid assets available to a firm (Voss et al., 2008). Cash slack increases the flexibility of firms and enhances their ability to adapt to complex environments. For example, cash slack influences sales growth by firms' investment. Myers and Majluf (1984) argued that a firm's cash slack is valuable in that it gives the firm the ability to invest in projects that have a positive net present value, for shareholders, the value of a dollar invested by the firm will be much higher than the value of its reserves in this time. When there is less cash slack, the firm is more likely to forego investments because of the high cost of external financing. On the other hand, when a firm has a lot of cash slack, it means that such firm has enough resources to invest in innovation, especially continuous innovation, which can greatly enhance its sales (Sukumar et al., 2020). Firms with cash slack are well insulated from innovation risk and will be motivated to innovate regardless of whether the R&D succeeds or fails (Bruneel et al., 2016). Zona (2012) found that when firms face an economic crisis, the more cash they hold, the more they will step up their innovation activities for sales growth.

### 2.2 Hypotheses

#### I. Related variety and sales growth

Scholars have not achieved consensus about the relationship between related variety and sales growth. Such relationship could be either positive or negative. Both arguments receive some support.

According to regional economics, related variety can positively influence sales growth. Related variety brings two advantages to firms: improving the innovation

capacity and reduced transaction costs (Naldi et al., 2020; Solheim et al., 2018). Frenken et al. (2007) argued that knowledge spillovers occur mainly among complementary or similar industries. As knowledge and information diffuse across various industrial boundaries, they can reconfigure ideas and foster innovation from different perspectives (Carlino, 2001). Due to the relatively narrow cognitive distance between firms, related variety is particularly likely to promote positive externalities from knowledge and technology spillovers (Antonietti et al., 2014). Thus, related variety increases the propensity of firms to innovate, which are the base for future sales growth. Furthermore, related variety means that many peer firms are concentrated in the same geography. One significant benefit of geographic concentration is cost savings; such as sharing labor equipment, infrastructure, transportation, and distribution networks.

According to the resource-based view, as the level of related variety increases, it gradually diminishes the rarity, irreplaceability, imitability and value of the resources owned by firms. According to the resource-based view, the precondition for achieving sales growth is owning special resources (Hoskisson et al., 2018). When related variety is low, it means that most resources are mainly concentrated in one or few industries. In other words, such industries have monopoly power in resources (Verbeke & Yuan, 2013). In such case, firms can easily obtain high sales growth. When related variety becomes large, more firms in related industries are involving in competition for valuable and rare resources. This makes realizing sales growth very hard. Furthermore, due to geographical proximity and industrial relatedness, firms can easily observe one another's behaviors and performance. This means that firms have few possibilities to maintain resources that cannot be imitated and replaced by other firms (Sepulveda & Gabrielsson, 2013). In one word, drawing on the resource-based view, increasing related variety is unhelpful for firms to maintain specific resources, which then does not benefit firms' sales growth.

Since both regional economics and the resource-based view make sense, we advance two competing hypotheses:

Hypothesis 1a: Related variety is positively related to firms' sales growth

Hypothesis 1b: Related variety is negatively related to firms' sales growth

## II. Related variety and cash slack

The low level of related variety leads to asymmetric information between firms and banks, which results in adverse selection and moral hazard, and thus restrict firms from obtaining financing from banks to accumulate cash slack (Farremensa & Ljungqvist, 2016). Regarding adverse selection, the low level of related variety means that there are few similar industries. In this case, collecting information on such firms' is difficult, which prevents banks from doing comprehensive credit assessment on firms operating conditions (Saeed & Sameer, 2015). Banks then have no choice but to increase loan interest rates to reduce risks (Saeed & Sameer, 2015), which increases the financing costs of firms. Regarding moral hazards, after obtaining bank loans, firms may invest in high-risk projects in order to develop rapidly, and these high-risk projects may cause the firm to fail to repay the loan on time. Therefore, banks usually take some measures

to avoid moral hazards (Dellariccia & Marquez, 2004), such as increasing restrictions on loans and reducing the amount of loans. However, the asymmetric information between firms and banks can decrease as related variety increases (Bennardo et al., 2015). On the one hand, higher related variety means that similar firms can share information in the region, which allows banks to collect detailed information about firms in a variety of ways, such as firm associations, suppliers, etc. (Antonietti et al., 2014). On the other hand, a reduction of the uncertainty about the firms' debt performance also ensues from higher related variety (Boateng et al., 2018), which stimulates the willingness of banks to provide credit. The majority of studies has shown that increased related variety improves firm performance, promoting firm innovation and reducing various costs that make operating conditions more stable (Cainelli & Ganau, 2019; Howell et al., 2016; Kanó et al., 2019). The increased level of related variety moderates the problem about asymmetric information between firms and banks, eases the financing constraints faced by firms and facilitates firms to accumulate cash slack through bank loans.

In addition, the asymmetric information between firms can be improved by higher related variety, which allows them to obtain financing from each other and accumulate respective cash slack. The increased level of related variety is always accompanied by the cluster of firms that are in the up, middle and low positions in the same industrial value chain, which deepens the supply and demand relationship between themselves, and with their common suppliers. In this case, firms are able to exchange more credible information through frequent transactions (Alessandrini et al., 2008).

To sum up, there is serious asymmetric information between firms and banks or between firms at low level of related variety, which restricts firm financing. The increased level of related variety promotes trust between firms or between firms and banks, and thus is conducive to the growth of firm cash slack through external financing.

Hypothesis 2: Related variety is positively related to firms' cash slack

### III. Cash slack and sales growth

This subsection focuses on the relationship between firms' cash slack and sales growth from the perspective of agency problem and investment behavior, with both boosting sales growth.

Building on the agency theory, the relationship between managers and shareholders belongs to the "principal-agent" relationship due to the separation of ownership and control. Managers have motivation to actively expand the scale of firm to pursue sales growth for satisfying the private interests owing to the existence of the agency problem (Van de Ven et al., 2007). Especially with the continuous accumulation of cash slack, this motivation would become more intense. Thus, they make decisions at the expense of the interests of their clients to maximize their own benefits (Daidj, 2017), which include building personal reputation, job promotion, and increasing compensation (Barnea & Rubin, 2010). Under this situation, managers, as the actual controllers of firms, would pursue sales growth via a series of capital expenditures, such as increasing investment in R&D (Park & Kwon, 2018), or increasing investment in both tangible resources such as logistics, distribution, information systems, etc., and

intangible resources such as training, product development, brand, etc. (Pucci et al., 2015). If there is a large amount of cash slack, this may lead firms to grow beyond their optimal size (Klasa et al., 2015). Regardless of the eventual outcome of the firm, high sales growth is always an obvious manifestation of this scale-up.

Apart from agency problems, seizing good investment opportunities is also helpful for accumulating cash slack to pursue sales growth. Investment is one of the core means driving the growth of firm capital (Gradzewicz, 2018), and sufficient cash slack can make firms facing financing constraints to obtain good investment opportunities (Klasa et al., 2015). In addition, in order to pursue sales growth, firms would conduct internal investment, such as investment in R&D, marketing activities and so on. R&D in product and technology help firms maintain core competitiveness and promote sales growth (Goedhuys et al., 2016). However, compared with external investment, R&D investments are more related to the development of basic knowledge application, which has the characteristics of high cost, long cycle and high risk. Thus long-term exploration and huge funds are required for firms to support R&D investment (Baldi & Bodmer, 2018). Cash slack entitles firms high flexibility to convert it into R&D resources in a short period of time quickly (Wiengarten et al., 2017). That is, cash slack acts as a “buffer; it allows firms to carry out R&D activities in multiple fields at the same time; it reduces adjustment costs; and provides a stable environment for firms. Beside, firms’ advertising investment (Kim & Bettis, 2014), sales personnel training, as well as other activities to improve sales growth (Vanacker et al., 2017) also need the support of sufficient cash slack. Therefore, whether it is internal or external investment behavior of firms, sufficient cash slack can boost the cultivation of new markets, research and development of new products and marketing. These behaviors can enhance the core competitiveness of firms and enable firms to obtain a more favorable position in obtaining sales growth.

Hypothesis 3: Cash slack is positively related to firms’ sales growth

### 3. Methodology

#### 3.1 Research context and data sources

We choose Norway as our research objective. Norway as a highly industrialized country provides an ideal sample for studying regional industrial structure (i.e., related variety). Secondary industry plays an important role in Norway’s national economy. For example, offshore petroleum, maritime industry, hydro-power energy and metallurgy are Norway’s representative industries. The different development degrees of these industries make the related variety in the municipalities significantly distinct, which facilitates our study on the impact of them on firm performances. Previous literature on related variety has mainly focused on the countries at continental Europe (Lazzeretti et al., 2010), United States (Castaldi et al., 2015) and Latin America (Silva et al., 2019). Studying Norway can enhance knowledge of related variety perspective on small countries, extending the theoretical generalizability of the related variety perspective.

We collected data from the following two sources: (1) Orbis Global Firm Database, which was developed by Bureau van Dijk, an analysis firm owned by Moody, and



provides firm-level data. It collects and processes information from 300 million firms all over the world (La Rocca et al., 2019); (2) Norwegian Bureau of Statistics (<https://www.ssb.no/en/statbank>), which provides municipal demographics and economic data. From this website, we got data on unemployment and regional surplus data. In one word, we obtained an unbalanced panel data, containing 100371 firm-level observations for the period 2015 to 2017 in 16 Norwegian municipalities (Aalesund, Asker, Baerum, Bergen, Bodo, Drammen, Fredrikstad, Kristiansand, Moss, Oslo, Sandnes, Sarpsborg, Skien, Stavanger, Toensberg, Tromsø).

### 3.2 Variables

#### 3.2.1 Dependent variables

Following Amason et al. (2006) and Cai et al. (2013), firms' sales growth is set as the dependent variable. Sales growth is a key proxy variable to measure firm performances, which indicates the firm's market possession and predicts the trend of business expansion. Generally, high sales growth implies that a firm is expanding its market shares. If a firm's sales growth starts to decline, it may suggest that such firms meet business challenges or enter into a recessionary phase. Thus, sales growth is a critical indicator, which can directly reflect whether a firm's business is in expansion or in decline. Equation (1) shows that how sales growth is quantified.

$$\text{Sales growth}_{i,t} = \frac{\text{Sales}_{i,t} - \text{Sales}_{i,t-1}}{\text{Sales}_{i,t-1}} \quad (1)$$

Where  $\text{Sales growth}_{i,t}$  refers to the sales growth of firm  $i$  in year  $t$ ;  $\text{Sales}_{i,t}$  and  $\text{Sales}_{i,t-1}$  refer to the sales of firm  $i$  in year  $t$  and  $t - 1$ , respectively.

#### 3.2.2 Independent Variables

Empirically, using the Standard Industrial Classification (SIC) scheme, Frenken et al. (2007) measured related variety as the average entropy across the number of employees in 5-digit sectors within each 2-digit industry. Similarly, using North American Industrial Classification System (NAICS), we defined a city's level of related variety as the weighted sum of the entropy across the number of employees at the 4-digit sectors within each 2-digit industry. Each 4-digit sector  $j$  belong to only a 2-digit industry  $S_g$ , where  $g = 1, \dots, G$ . Then we sum 4-digit shares of employees:

$$p_j = \frac{\text{Employees under sub - industry } j \text{ in a certain city}}{\text{Employees in that city}} \quad (2)$$

And obtain the 2-digit shares:

$$P_g = \sum_{j \in S_g} p_j \quad (3)$$

The entropy of related variety within each two-digit industry is as follows:

$$RV = \sum_{g=1}^G P_g H_g \quad (4)$$

where:

$$H_g = \sum_{j \in S_g} \frac{p_j}{P_g} \ln \left( \frac{1}{p_j/P_g} \right) \quad (5)$$

### 3.2.3 Mediator

We choose cash slack as the mediator, which refers to the proportion of cash that exceeds the normal cash holdings. Opler et al. (1999) obtained cash slack by subtracting the expected cash holdings from the existing cash holdings, where the former is calculated through firms' characteristic variables. Following this path, we can find a suitable indicator for cash slack. However, it has also been suggested that cash slack is always a dynamically relative value, rather than a statically absolute value (Bromiley, 1991; March & Shapira, 1987). We calculate cash slack by comparing differences in the use of cash between the firm and its sub-industry.

The mathematical expression is as follows:

$$\text{Cash slack}_{i,t} = \frac{\text{Cash flow}_{i,t}}{\text{Total assets}_{i,t}} - \frac{\text{mean}(\text{Cash flow})_{j,t,c}}{\text{mean}(\text{Total assets})_{j,t,c}} \quad (6)$$

Where  $\text{Cash flow}_{i,t}$  and  $\text{Total assets}_{i,t}$  respectively refer to the cash flow and total assets of firm  $i$  belonging to sub-industry  $j$  and located in municipality  $c$  in year  $t$ ;  $\text{mean}(\text{Cash flow})_{j,t,c}$  and  $\text{mean}(\text{Total assets})_{j,t,c}$  refer to the average cash flow and average total assets of sub-industry  $j$  located in municipality  $c$  in year  $t$ , respectively.

### 3.2.3 Control variables

We set control variables both at the firm level and at the municipality level. For the firm level, total assets, current liability, cash flow and the number of employees are taken into account. The mediator, cash slack, is obtained from cash flow and total assets, thus they are the key factors affecting cash slack and sales growth. Current liability broadly reflects the short-term solvency closely related to firms' sales growth (Catao & Milesiferretti, 2014). Finally, we also control for the number of employees reflecting the size of a firm (Kang et al., 2016). For the municipality level, we control for the number of unemployed and fiscal surplus, both of which reflect the resources slack of a municipality and therefore are closely related to the sales growth of local firms (Alesina & Alberto, 2000).

Table 1 shows the definitions for all variables mentioned above. Tables 2 and 3 provide the descriptive statistics and the correlation matrix, respectively.

Table 1 Definition of Variables

	Definition	Notes
<b>Dependent variables</b>		
Growth	Firm's annual sales growth	
<b>Independent variables</b>		
RV	Related variety calculated by entropy	See Equation (4)
<b>Mediator</b>		
Cslack	Cash slack	See Equation (6)
<b>Control variables</b>		
Tasset	Firm's total assets	Unit: million USD

Clabilities	Firm's current liability	Unit: million USD
Cash	Firm's cash flow	Unit: million USD
Employees	The number of employees in a firm	Unit: thousand people
Unemp	The number of unemployed in a municipality	Unit: thousand people
Surplus	Municipality's fiscal surplus	Unit: million USD

Table 2 Descriptive Statistics

Variable	N	Mean	Min	P25	P50	P75	Max
Growth	100371	0.228	-1.000	-0.131	0.035	0.210	12.286
RV	100371	1.340	0.909	1.187	1.295	1.569	1.621
Cslack	100371	-0.008	-1.249	-0.199	-0.051	0.165	2.781
Tasset	100371	1.938	0.006	0.127	0.393	1.311	100.299
Clabilities	100371	0.718	0.001	0.053	0.153	0.485	32.571
Emp	100371	0.016	0.001	0.002	0.005	0.013	4.421
Cash	100371	0.303	0.000	0.024	0.081	0.258	8.644
Unemp	100371	5.049	0.396	1.130	3.884	9.439	11.494
Surplus	100371	468.468	5.748	96.958	231.650	675.266	1640.196

Table 3 Correlation Matrix

	Growth	RV	Cslack	Tasset	Clabilities	Emp	Cash	Unemp
Growth	1							
RV	0.023	1						
Cslack	0.014	-0.006	1					
Tasset	-0.018	0.026	-0.157	1				
Clabilities	-0.017	0.041	-0.142	0.655	1			
Emp	-0.023	0.024	-0.076	0.247	0.397	1		
Cash	-0.024	0.056	0.143	0.463	0.438	0.244	1	
Unemp	0.011	0.812	-0.008	0.046	0.063	0.044	0.083	1
Surplus	0.040	0.640	-0.003	0.033	0.046	0.020	0.063	0.699

### 3.3 Constructing regression models: Causal steps approach

In order to investigate how related variety affects firms' sales growth through cash slack, the present paper used the causal steps approach, which was proposed by (Baron & Kenny, 1986) and has been the most mainstream and basic method to examine the mediation effect. In addition to this basic method, a relatively new method, causal mediation analysis and sensitivity analysis, were also deployed in the robustness tests.

For the causal steps approach, we applied the ordinary least squares (OLS) regression model to each of the three steps with time fixed effect and individual fixed effect. The fixed effects model goes some way to mitigating the endogeneity posed by omitted variables, as it controls for the heterogeneity that changes over different years and different firms (Bell et al., 2019). The regression models are set as follows.

First stage:

$$\text{Growth}_{i,t} = a_0 + a_1RV_{i,t} + a_2Z_{i,t} + \mu_t + \varphi_i + e_{i,t} \quad (7)$$

Second stage:

$$\text{Cslack}_{i,t} = b_0 + b_1RV_{i,t} + b_2Z_{i,t} + \mu_t + \varphi_i + h_{i,t} \quad (8)$$

Third stage:

$$\text{Growth}_{i,t} = c_0 + c_1 RV_{i,t} + c_2 \text{Cslack}_{i,t} + c_3 Z_{i,t} + \mu_t + \varphi_i + k_{i,t} \quad (9)$$

Where  $RV_{i,t}$  refers to related variety of the region, where firm  $i$  is located in year  $t$ ;  $a_0, b_0, c_0$  refers to constant terms.  $Z_{i,t}$  refers to the matrix of control variables shown in Table 1;  $\varphi_i$  is the individual fixed effect, and  $\mu_t$  is the time fixed effect.  $e_{i,t}, h_{i,t}, k_{i,t}$  are the error terms. Here, to be more specific, the direct effect is equal to  $\hat{c}_1$ ; the indirect effect (mediation effect) is equal to  $\hat{b}_1 * \hat{c}_2$ ; thus, the total effect is equal to  $\hat{a}_1 = \hat{c}_1 + \hat{b}_1 * \hat{c}_2$ . However, it is important to note that according to Zhao et al. (2010) even if the total effect is insignificant at the first stage, it does not mean that there is no causality between related variety and sales growth. The case described above may be caused by a possible fact that the sign directions of direct and mediation effects are opposite and their magnitude is close, leading to a counterbalanced total effect called “suppression effects” by Kenny et al. (2003) and Mackinnon et al. (2000). If at least one estimate of  $\hat{b}_1$  and  $\hat{c}_2$  is statistically insignificant, it is necessary to use Bootstrap method to further examine whether the confidence interval of  $\hat{b}_1 * \hat{c}_2$  excludes zero. Another issue to note is that if both the mediation and direct effects are statistically significant, then the mediator plays a partial mediating role in the total effect, which does not exclude the possibility of other mediators. Zhao et al. (2010) suggested illustrating this possibility in the discussion section; if only the former significant, then it plays a full mediating role.

#### 4. Regression results and Robustness tests

##### 4.1 Regression results

We first conducted three OLS regressions with FE model constructed as Equations (7), (8) and (9), and all regression results are shown in Table 4. The column (1) shows the estimation result for Equation (7). Related variety is a significant negative predictor of firm sales growth ( $\hat{a}_1 = -0.332, p < 0.01$ ), thus **the Hypothesis 1a receives support**. That is, in the context of the present paper, it is resource-based view that explains this relationship precisely, rather than relevant theories from regional economics. After estimated Equation (8), the **regression result provides significant evidence for Hypothesis 2**, that is, the mediator (namely cash slack) is positively related to related variety, although the coefficient is rather small ( $\hat{b}_1 = 0.031, p < 0.1$ , see column (2)). When both the independent variable and mediator are put into the regression model (namely Equation (9)), the coefficients of both are statistically significant ( $\hat{c}_1 = -0.340, \hat{c}_2 = 0.244$  and  $p < 0.01$  for both, see column (3)), suggesting that cash slack plays a partially mediating role in the effect of related variety on firm sales growth. **Hypothesis 3 therefore is verified**. In summary, the direct effect of related variety on firm sales growth is equal to  $-0.340$  (namely  $\hat{c}_1$ ); the indirect effect (mediation effect) is equal to  $0.008$  (namely  $\hat{b}_1 * \hat{c}_2$ ); the total effect is equal to  $-0.332$  (namely  $\hat{a}_1 = \hat{c}_1 + \hat{b}_1 * \hat{c}_2$ ). By calculating  $|(\hat{b}_1 * \hat{c}_2) / \hat{c}_1|$ , we know the 2.353% impact of related variety on sales growth is positively mediated by cash slack.

Table 4 Causal Steps Approach

(1)	(2)	(3)
First stage	Second stage	Third stage

Variables	Growth	Cslack	Growth
RV	-0.332*** (0.115)	0.031* (0.017)	-0.340*** (0.115)
Cslack			0.244*** (0.033)
Tasset	0.019*** (0.004)	-0.007*** (0.001)	0.020*** (0.004)
Clabilities	0.023*** (0.007)	-0.004*** (0.001)	0.024*** (0.007)
Emp	0.561*** (0.187)	-0.056*** (0.020)	0.574*** (0.187)
Cash	0.079*** (0.010)	0.126*** (0.002)	0.049*** (0.011)
Unemp	0.016 (0.011)	-0.001 (0.001)	0.016 (0.011)
Surplus	-0.000** (0.000)	-0.000 (0.000)	-0.000** (0.000)
Constant	0.485*** (0.153)	-0.059*** (0.022)	0.499*** (0.153)
FE	Yes	Yes	Yes
Year	Yes	Yes	Yes
Observations	100,371	100,371	100,371
R-squared	0.007	0.100	0.008

Note: robust, heteroskedasticity-adjusted standard errors in parentheses; \*, \*\*, and \*\*\* represent statistical significance at the 10%, 5% and 1% level, respectively.

## 4.2 Robustness tests

### 4.2.1 Causal mediation analysis

There is a noticeable problem for the causal steps approach to analyze mediation effect: this traditional approach produces valid estimation only under the premise of the sequential ignorability (SI) assumption, which is, however, difficult to verify (Hicks & Tingley, 2011). Sequential ignorability includes two assumptions. Firstly, given the observed control variables, the observed independent variables are independent of all unobserved mediators and dependent variables. Secondly, given the observed control variables and independent variables, the observed mediators are also independent of all unobserved dependent variables (Imai et al., 2010). The first assumption, which is common in research, is what we usually refer to as the exogeneity. However, the second assumption is difficult to satisfy even in a randomized experiment. Causal mediation analysis developed by Imai et al. (2010), while also unable to verify the sequential ignorability assumption, allows for a sensitivity analysis for the degree of violation of the assumption after calculating the average causal mediation effect (ACME) of interest. Here, we mainly introduce how to calculate ACME. The new method is first applied to the case where the independent variable is binary, and is based on a counterfactual

framework to calculate the ACME. Fortunately, it can also be extended to the case where the independent variable is continuous. Referring to Imai et al. (2010), the quantities of interested in the present paper can be set in the following forms.

Average causal mediation effect (ACME):

$$\bar{\delta}_{i,t}(x_{i,t}; x_1, x_0) = E\left(Y_{i,t}(x_{i,t}, M_{i,t}(x_1)) - Y_{i,t}(x_{i,t}, M_{i,t}(x_0))\right) \quad (10)$$

Average direct effect (ADE):

$$\bar{\vartheta}_{i,t}(x_{i,t}; x_1, x_0) = E\left(Y_{i,t}(x_1, M_{i,t}(x_{i,t})) - Y_{i,t}(x_0, M_{i,t}(x_{i,t}))\right) \quad (11)$$

Average total effect (ATE):

$$\begin{aligned} \bar{\tau}_{i,t} &= E\left(Y_{i,t}(x_1, M_{i,t}(x_1)) - Y_{i,t}(x_0, M_{i,t}(x_0))\right) \\ &= \frac{1}{2} \sum_{x_t=x_0}^{x_1} [\bar{\delta}_{i,t}(x_{i,t}; x_1, x_0) + \bar{\vartheta}_{i,t}(x_{i,t}; x_1, x_0)] \end{aligned} \quad (12)$$

Where  $x_{i,t}$  refers to the value of related variety for firm  $i$  in the year  $t$ ;  $x_0$  and  $x_1$  denote any two different value of related variety, namely  $x_0 \neq x_1$ . For the firm  $i$ , if  $x_{i,t} = x_1$  is the observed value of related variety in the year  $t$ ,  $x_0$  cannot be observed and it just be a potential value for  $x_{i,t}$ , and vice versa. Therefore we can only get the observed values of mediator and dependent variable,  $M_{i,t}(x_1)$  and  $Y_{i,t}(x_{i,t}, M_{i,t}(x_1))$ , but not  $M_{i,t}(x_0)$  and  $Y_{i,t}(x_{i,t}, M_{i,t}(x_0))$ . To address this problem, the algorithm developed by Hicks and Tingley (2011), simulates the unobserved potential values based on sampling distribution and the quasi-Bayesian Monte Carlo approximation to compute the quantities of interest presented in Formulas (10), (11) and (12), after fitting Equations (8) and (9) using the observed values.

As we can see from Table 5, while there are subtle differences in the magnitude of these interested coefficients led by sharp decrease in sample size between the causal mediation analysis and the causal steps approach, they are generally consistent with each other in the sign and significance. Thus, although all the average direct effects (ADE=-0.655), average causal mediation effects (ACME=0.028) and average total effects (ATE=ACME+ADE=-0.627) are larger than all the direct effects ( $\hat{c}_1 = -0.340$ ), indirect effects ( $\hat{b}_1 * \hat{c}_2 = 0.008$ ) and total effect ( $\hat{a}_1 = \hat{c}_1 + \hat{b}_1 * \hat{c}_2 = -0.332$ ) respectively, the positive share of cash slack in the influence of related variety on sales growth is very close between the two methods (2.353% for the causal steps approach and 4.149% for the causal mediation analysis, even the latter is larger than the former). In summary, Hypotheses 1a, 2, and 3 are verified again by the causal mediation analysis.

#### 4.2.2 Sensitivity analysis

The unique advantage of the causal mediation analysis over the causal steps approach is that it allows for a sensitivity analysis. Imai et al. (2010) used  $\rho = \text{corr}(h_{i,t}, k_{i,t})$  ( $-1 < \rho < 1$ ) as a sensitivity parameter to measure the degree of violation of the sequential ignorability (SI) assumption. Here  $h_{i,t}$  and  $k_{i,t}$  are the

error terms of Equation (8) and (9), respectively. When  $\rho = 0$ , the SI assumption is satisfied, that is  $ACME = 0.028$  presented in Table 5; however when  $\rho \neq 0$ , there is omitted variables that are related to both the observed mediator  $M_{i,t}(x_1)$  and unobserved potential dependent variable  $Y_{i,t}(x_{i,t}, M_{i,t}(x_0))$  (Imai et al., 2010).

Although the true value of  $\rho$  is unknown, the algorithm developed by Hicks and Tingley (2011) provided the possibility of calculating the value of  $\rho$  for which ACME is zero. Thus we can examine the degree to which violating the SI assumption would reverse the initial conclusion.

As we can see from Figure 3, when  $\rho = 0.036$ ,  $ACME = 0$  (illustrated by the long dashed line); and the positive direction of ACME concluded under SI assumption (illustrated by the short dashed line,  $\rho = 0$  and  $ACME=0.028$ ) remain robust unless  $\rho > 0$  or  $\rho < -0.7$ . If taking into considerations the confidence interval of ACME, the initial conclusion still robust when  $-0.2 \leq \rho \leq 0$ . Therefore, even if the sensitivity parameter does not solve the endogeneity posed by the omitted variables, it gives us an insight into the extent to which the violation of the SI assumption can still maintain the robustness of the initial conclusion for ACME drawn from Subsection 4.1, namely cash slack plays a positive mediating role in the impact of related variety on firms' sales growth.

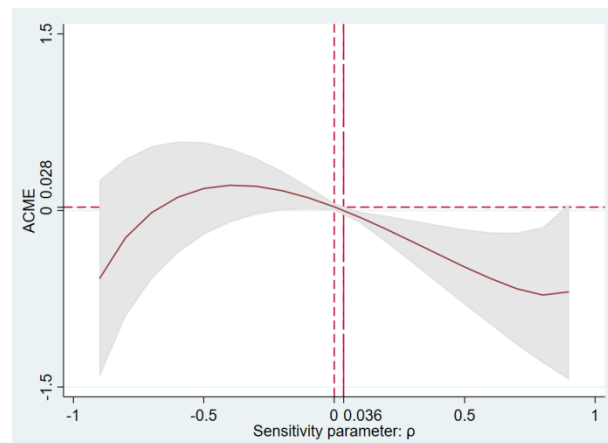
Table 5 Causal Mediation Analysis

	(1)	(2)
Variables	Cslack	Growth
RV	0.109** (0.055)	-0.643* (0.367)
Cslack		0.259*** (0.096)
Tasset	-0.004* (0.002)	0.008 (0.012)
Clabilities	-0.008*** (0.003)	-0.035 (0.022)
Emp	-0.033 (0.053)	0.247 (0.290)
Cash	0.125*** (0.008)	0.049* (1.530)
Unemp	0.002 (0.005)	-0.031 (0.032)
Surplus	-0.000 (0.000)	-0.000** (0.000)
Constant	-0.183** (0.072)	1.182*** (0.483)
FE	Yes	Yes
Year	Yes	Yes
Observations	10,000	10,000
R-squared	0.101	0.008

ACME	0.028
ADE	-0.655
ATE	-0.627
% of ACME	4.149%

Note: robust, heteroskedasticity-adjusted standard errors in parentheses; \*, \*\*, and \*\*\* represent statistical significance at the 10%, 5% and 1% level, respectively. And the % of ACME, the ATE are subtly inconsistent with  $|ACME/ADE|$ ,  $ACME+ADE$  due to round-up.

Figure 3 The Value of ACME under Different Sensitive Parameter  $\rho$



## 5. Conclusions

In the present paper, using data on Norwegian firms, we studied the relationship between the level of related variety and firms' sales growth, as well as its linking mechanism. According to the resource-based view, asymmetric information, and agent problem, together with investment behavior, we found that there is a negative influence of related variety on sales growth, and cash slack plays a significant positive mediating role in this relationship. This conclusion is rather robust after we adopted a new estimation method.

Many scholars have followed in the footsteps of Frenken et al. (2007) and studied the development of regional economics from the perspective of related variety. For example, Aarstad and Kvitastein (2019) focused on the impact of related variety on regional entrepreneurial path dependency; Asheim et al. (2011) on regional advantages; Castaldi et al. (2015) on regional patenting, and others. From the above enumeration, we know that most of the studies focus more on the impact of related variety from the regional level, which is reasonable since it is characterized by regional features. These studies not only refine the initial thinking about related variety, but also provide insights into regional development as a whole. However, along with the reminders from Content and Frenken (2016), we have to take note of the fact that micro-level impact has received little attention in the field of related variety, such as firm performance. Because firms are the smallest units in the industrial structure of a certain region, their distribution determines the local level of related variety, and their performance is inevitably influenced by the local industrial environment. If research on related variety do not provide some useful advice on location as well as operations for firms, then the theory about related variety may be missing the microeconomic component. What the



present study attempts to do is to provide microeconomic evidence for related variety. Although there have already been a few researches coming to the consistent conclusion that related variety positively affects firm performance (Antonietti & Cainelli, 2011; Cainelli & Ganau, 2019), we still raised an counterintuitive question: is the impact of related variety on sales growth really positive from the perspective of the resource-based view? The empirical result is supportive for the fact that the high level of related variety impedes sales growth, with the loss of firms' monopoly and the intension of competence between them.

As mentioned above, we are not the first to examine the role of related variety at the micro level. A few have taken the lead in thinking about the impact of related variety on firm performance (Strambach & Klement, 2012), but ignored the mechanism for the causality. The importance of mechanism analysis is reflected in the fact that it tells firms through which channel to achieve high performance. Therefore, we fill this gap via mechanism analysis. From the perspectives of asymmetric information, agent problem as well as investment behavior, we identified that while the level of related variety is negatively correlated with sales growth, firm can still mitigate this kind of unfavorable condition by accumulating their cash slack.

The above causal and mechanism analysis have made theoretical contributions and provided practical implications. Theoretical contributions mainly include the following three aspects: Firstly, this paper shifts the perspective of research on related variety from the macro level to the micro level, focusing on the question about how industry structure as an external environment affects firm performance, which enriches the relevant theory of related variety. Secondly, through a mechanism analysis, this paper provides a reasonable explanation for the relationship between related variety and firms' sales growth, i.e., the accumulation of cash slack. Finally, we also identify direct evidence for the positive effect of related variety on firms' cash slack, which has not appeared in the previous literature. That is, we directly link the level of related variety at the regional level to the financial resources at the firm level, which means a further enrichment for the theory of related variety. Practical implications mainly include the following two aspects: for policymakers, when planning the industrial structure of a region, it is not a good idea to develop policies that attract more clusters of similar and complementary sub-industries and firm. For firms, it would be of great benefit to the future development to choose a region with low level of related variety when making location decisions. When already in the region with high related variety, they can mitigate the negative impact of high related variety on sales growth by building up cash slack.

At the same time, there are some limitations of this study that should have implications for future research. Firstly, when conducting the robustness tests, we had to select a subsample of 10,000 out of the full sample of 100,371 randomly due to the specificity and complexity of causal mediation analysis and sensitivity analysis. Although the results obtained by this new method are consistent with that by the causal step approach in the baseline regressions, it is necessary to consider whether this subsample is really representative, since the full sample covers 42,909 firms in 16 Norwegian municipalities from 2015 to 2017. Thus, future researchers need to consider

looking for a better sample when using causal mediation analysis and sensitivity analysis. Secondly, while the positive mediation effect of cash slack is significant, the negative direct effect of related variety on sales growth is significant simultaneously, and finally the total effect is also significantly negative. As Zhao et al. (2010) has identified, this partial mediation effect implies that there are other important negative mediators between related variety and sales growth, which also provides an important direction for future research.

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