USING MULTIPLE GROUP STRUCTURAL MODEL FOR TESTING DIFFERENCES IN ABSORPTIVE AND INNOVATIVE CAPABILITIES BETWEEN LARGE AND MEDIUM SIZED FIRMS

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Abstract

In the proposed model, absorptive and innovative capabilities of the firm determine firm's performance level. Absorptive capability construct consists of four latent variables: knowledge acquisition, assimilation, transformation and exploitation. Innovative capability consists of five manifest variables: developing new products or services, developing new methods of production, risk-taking by key executives, market innovativeness and innovative strategic orientation. Absorptive capability and innovative capability both have direct influence on firm's performance. Also, the interdependence of absorptive capability and innovative capability is assumed. For testing construct validity and theoretical relationships among variables structural equation omdeling is used. Model is assessed using absolute and incremental fit indices. Multiple group modeling is used to determine whether or not the grouping variable, in this case firm size, has any influence on the structural equation model for the observed variables.

Key words: *Strategic management, Structural equation modeling, Multiple group models, Absorptive capability, Innovative capability, Firm size*

1. INTRODUCTION

According to the proposed theoretical model, firm's performance level is determined by its absorptive and innovative capabilities, which are interdependent. Absorptive capability is based on knowledge (Newey and Zahra, 2009), and it enables firm to recognize the value of new, external information, absorb it and use it (Cohen and Levinthal, 1990; Hou and Chang, 2010; Wang and Ahmed, 2007). It consists of knowledge acquisition, assimilation, transformation and exploitation (Wang and Ahmed, 2007; Zahra and George, 2002). Innovative capability through strategic innovative orientation enables

new products and markets development (Wang and Ahmed, 2004, 2007). It includes development of new products and services, development of new production methods, risk-taking by key managers, market innovation and firm's innovative strategic orientation (Miller and Friesen, 1983; Capone, 1992; Wang and Ahmed, 2007). Also, the difference in absorptive and innovative capabilities and their impact on firm's performance with respect to firm's size is analyzed. First, full group structural model is examined, as well as its fit indices, convergent and discriminant validity. Considering that this type of model can mask effects specific to firm's size, multiple group structural equation model is examined to test whether the size of the firm has any influence on relationship between absorptive and innovative capabilities and firm performance.

2. LITERATURE REVIEW

Absorptive capability refers to firm's ability to recognize the value of new, external information, absorb it and use it (Cohen and Levinthal, 1990; Hou and Chang, 2010; Wang and Ahmed, 2007). According to Newey and Zahra (2009), absorptive capability is a competence based on knowledge that supports functioning of operational and dynamic capabilities. Results of empirical studies have shown that it's necessary for firm's success (George, 2005; Salvato, 2003, Woiceshyn and Daellenbach, 2005), but have not validated a multidimensional construct of absorptive capability (Wang and Ahmed, 2007).

Innovative capability refers to the ability of new products and markets development through *"aligning strategic innovative orientation with innovative behaviors and processes"* (Wang and Ahmed, 2004, 2007). From above mentioned definition it can be seen that innovative capability consists of several dimensions. Prior research has mainly investigated different combinations of innovative capability dimensions (Capon et al., 1992; Miller and Friesen, 1983). Results of these studies emphasize the importance of innovative capabilities for firm's evolution and survival, especially with respect to dynamic environment and constant change (Deeds et al., 1999; Delmas, 1999; Petroni, 1997; Tripsas, 1997).

3. METHOD

3.1. Sample

This study uses primary data collected from large and medium sized Croatian firms with more than 100 employees. Such firms were identified based on the data from the Croatian Chamber of Economy, which resulted with population of 1017 firms. Online and mail surveys were sent simultaneously,

which enabled managers to choose the way they want to participate. A total of 265 usable surveys were collected. That resulted with the response rate of 26.06%, acceptable for this type of research (Drnevich and Kriauciunas, 2011; Protogerou, Caloghirou and Lioukas, 2008). From 265 usable questionnaires, 144 (54.3%) were collected through mail survey, while 121 (45.7%) questionnaire was collected via online survey. Furthermore, there are 108 (40.8%) large, and 157 (59.2%) middle-sized firms in the sample, of which 46 (17.4%) firms are in the foreign and 219 (82.6%) in the domestic ownership.

3.2. Measures

Absorptive capability was operationalized according to theoretical assumptions by Wang and Ahmed (2007) and Zahra and George 2002), through following manifest variables: knowledge acquisition (AB1), knowledge assimilation (AB2), knowledge transformation (AB3), and knowledge exploitation (AB4).

Innovative capability was operationalized according to Miller and Friesen (1983), Capone (1992) and Wang and Ahmed (2007) through following variables: development of new products and services (IN1), development of new production methods (IN2), risk-taking by key managers (IN3), market innovation (IN4), and firm's innovative strategic orientation (IN5).

Given that the perceptual measures of performance correlate with objective measures (Powell, 1992), firm's performance was operationalized through managers' perceptions of main performance categories: sales (PERF1); sales growth (PERF2); profitability (PERF3); market share (PERF4), increase in market share (PERF5) and sustainability of achieved performance levels (PERF6).

The scales were assessed on a five-point Likert-type scale ranging from 1 = much worse than competitors to 5 = much better than competitors. Internal consistency of scales (reliability) was proved to be acceptable with Cronbach's α 0,878 for performance; 0,910 for absorptive capability and 0,872 for innovative capability.

3.3. Analyses

Lisrel 8.80 structural modelling program with ML estimation technique was used for all analyses. SEM analysis was conducted in one step, i.e. measurement and structural model were simultaneously assessed and tested. Proposed model is recursive structural model, i.e. a model in which all paths go from predicting the dependent variables. It consists of two exogenous latent constructs: absorptive capability and innovative capability and endogenous latent construct, i.e. firm's performance. There

are also 15 manifest variables in the model, which serve as indicators of latent variables. Model was tested for the full sample, as well as for medium and large firms in multiple group structural equation models. Overall model fit was assessed examining absolute fit indices, i.e. Chi-square statistics, root mean square residual (RMR), standardized root mean square residual (SRMR) and goodness of fit index (GFI), and incremental fit indices, i.e. comparative fit index (CFI), normed fit index (NFI), nonnormed fit index (NNFI) and relative fit index (RFI). For GFI, NFI, NNFI, CFI, RFI values above 0.90 indicate good fit, while for RMR, SRMS and RMSEA smaller values indicate better fit (Hair, 2005).

4. RESULTS

Factor loadings as well as the estimated path coefficients for the structural relationships hypothesized by the model (for the full sample) are presented in Figure 1. Variances of all error and disturbance terms were freed, and variances of the two exogenous factors (absorptive and innovative capability) were fixed at 1.00. Path coefficients between factors were freely estimated. Results show that all paths are significant and in expected direction. Direct effects of absorptive and innovative capability on firm's performance are shown in Figure 1,while indirect and total effects can be calculated. The size of an indirect effect is a function of direct effects that make it up, while the total effect is a sum of indirect and direct relationships between constructs (Hair, 2005). Indirect effect of absorptive capability on firm's performance equals 0.1995, which means that total effect is 0.460. Indirect effect of innovative capability on firm's performance equals 0.148, and total effect 0.498.

Construct validity of a proposed measurement theory is also examined. Construct validity refers to the extent in which a set of manifest variables actually reflects the theoretical latent construct that they are designed to measure. It consists of convergent and discriminant validity. The manifest variables that are indicators of a specific construct should share a high proportion of variance in common, known as convergent validity. Relative amount of convergent validity among item measures can be estimated though analyzing factor loadings, average variance extracted (AVE) and reliability (CR). In the case of high convergent validity, factor loadings should be statistically significant and 0.5 or higher, AVE should be 0.5 or higher, and CR higher than 0.6. From Figure 1 and Table 2 it can be seen that all above mentioned conditions are met. Discriminat validity refers to the extent to which a construct is truly distinct from other constructs. It can be assessed by comparing AVE of any two constructs with the square of correlation estimate between these constructs. If discriminate validity exists, AVE should be higher than squared correlations (Hair, 2005).

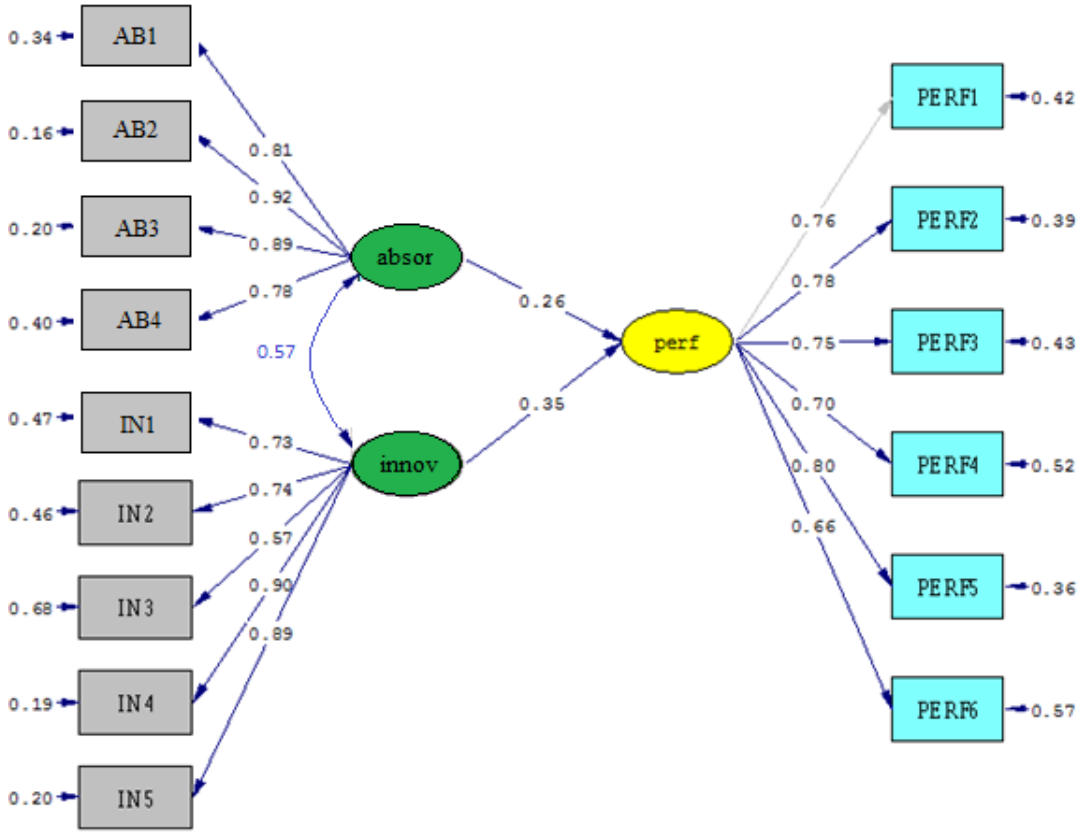

Figure 1: Standardized SEM model for full sample

From indicators shown in Table 1 it can be seen that SEM model fits data well, with NFI=0.943, NNFI=0.950, CFI=0.959, RFI=0.931, RMR=0.0452, SRMR=0.0589, GFI= 0.878 and RMSEA=0.090.

Table 1: Goodness of Fit Statistics for full sample

Chi-square	NFI	NNFI	CFI	RFI	RMR	SRMR	GFI	RMSEA
273.588 (87, 0.000)	0.943	0.950	0.959	0.931	0.0452	0.0589	0.878	0,090

Table 2: Construct validity for full sample

	AVE	CR	β^2, Φ^2
Absorptive capability	0.726	0.905	0.325, 0.068
Innovative capability	0.602	0.88	0.325, 0.123
Performance	0.534	0.732	0.068, 0.123

Since the full group model may mask effects specific to the firm's size, in this section a multiple group model comparing large and medium-sized firms is examined. In different words, multiple group structural equation modeling is used to assess whether or not the factor loadings and path estimates of the measurement model are invariant across two groups (medium and large firms).

First, joint unconstrained model for all groups were estimated (i.e. coefficients are allowed to vary freely across groups). In unconstrained model, structural relationships are specified in the both groups meaning that the model is equal across groups, but the coefficients in the relationships are estimated independently for each group. Error variances, and variances and covariances of the latent variables are not constrained to be equal to those in the first group, i.e. they are freely estimated for the each group. Standardized unconstrained model for medium sized firms is presented in Figure 2, while standardized unconstrained model for large firms is shown in Figure 3. All path estimates for large and medium-sized companies were significant, in expected direction and indicated much similarity in structural relationships as well as factor loadings.

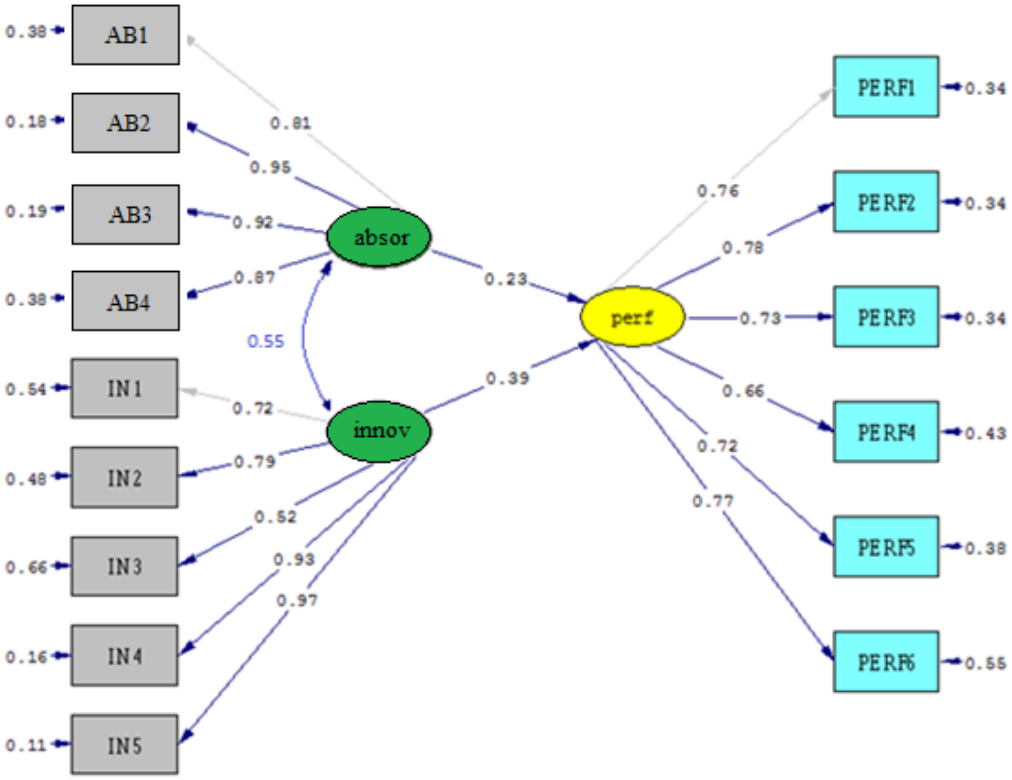

Figure 2: Standardized SEM model for medium sized firms (unconstrained)

Next step included estimation of a joined constrained model where the parameters across groups were constrained to be equal to each other. In the estimation of the constrained model, factorial structure and structural paths are the same across groups, i.e. they are omitted from the syntax in the second group, so LISREL assumes that they are the same as for the first group.

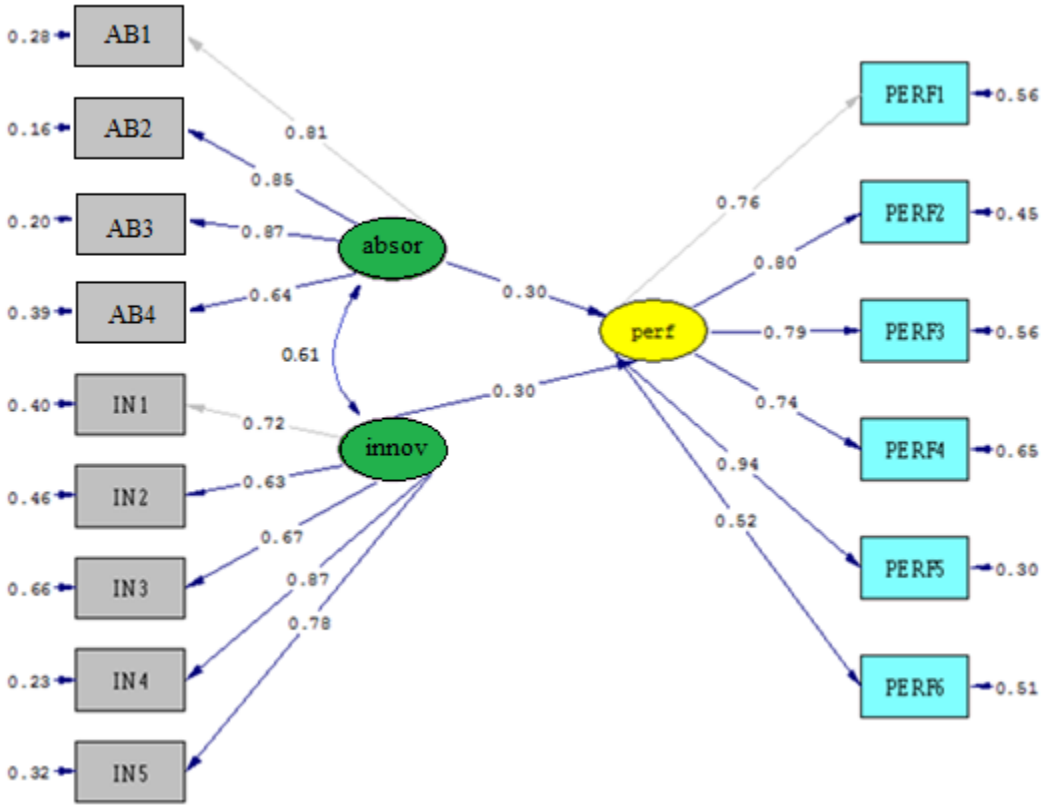

Figure 3: Standardized SEM model for large firms (unconstrained)

In Table 3 group goodness of fit statistics of unconstrained and constrained model for medium and large companies is presented, while global goodness of fit statistics for unconstrained and constrained model is shown in Table 4. It can be seen that, with the imposed equality constraints, a highly significant increase in chi-square was observed and other model fit indices (RMR, SRMR, GFI, NFI, CFI) were slightly diminished (for the unconstrained and constrained model, respectively).

Table 3: Group Goodness of Fit Statistics

		Contribution to chi-square	RMR	SRMR	GFI
Unconstrained model	medium	258.996	0.0520	0.0657	0.829
	large	160.378	0.0538	0.0709	0.852
Constrained model	medium	289.279	0.0667	0.0873	0.813
	large	196.044	0.0752	0.0958	0.825

Table 4: Global Goodness of Fit Statistics

	Chi square	NFI	NNFI	CFI	RFI
Unconstrained model	379.814 (176,0.000)	0.921	0.943	0.952	0.905
Constrained model	435.982 (205, 0.000)	0.908	0.943	0.945	0.906

Final step of multigroup comparison included comparing the fit of constrained model with a fit of an unconstrained model using the difference in Chi-square statistic. If the Chi-square difference statistic

does not reveal a significant difference between the unconstrained and constrained models, then it can be concluded that factor loadings and structural paths for large and medium-sized firms are identical. Test statistic value for the Chi-square difference test is difference between the goodness-of-fit Chi-square test values of the unconstrained and constrained multiple group SEM models, while associated degrees of freedom refer to the difference between the degrees of freedom of unconstrained and constrained multiple group SEM models. Difference between Chi-square of unconstrained and constrained multiple group SEM model equals $\Delta\chi^2$ =230.98, and difference in degrees of freedom is Δdf=29. With p less that 0.0001, it can be concluded that difference in factor loadings and path estimates for medium and large firms is extremely statistically significant, i.e. the factor loadings and path estimates for medium and large firm's are different, which means that unconstrained multiple group model is accepted.

Direct effect of innovative capability on firm's performance is greater than direct effect of absorptive capability on firm's performance for medium-sized firms while, for large firms, abovementioned effects are the same. Table 5 presents direct, indirect and total effects of absorptive and innovative capabilities on firm's performance for large and medium-sized firms.

Table 5: Direct, indirect and total effects - unconstrained multi-group models

	Medium firms		Large firms	
	Absorptive capability	Innovative capability	Absorptive capability	Innovative capability
Direct effect	0.23	0.39	0.30	0.30
Indirect effect	0.13	0.21	0.18	0.18
Total effect	0.36	0.60	0.48	0.48

By summing correlation between absorptive and innovative capability with their effects on firm's performance the size of their indirect effects on firm's performance can be calculated. For medium-sized firms, indirect effect of absorptive capability on firm's performance is 0.13, and indirect effect of innovative capability on firm's performance is 0.21. That means that total effect of absorptive capability on performance equals 0.36, and total effect of innovative capability on firm's size equals 0.60 for medium-sized firms. For large companies, indirect effect of absorptive capability on performance is 0.18, and total effect is 0.48. The effect of innovative capability is the same.
Indicators of construct validity for the unconstrained multiple group models are shown in Table 6.

Convergent and discriminant validity are confirmed for both models, since average variance extracted (AVE) is larger than 0.5, construct reliability (CR) is larger than 0.6, and squared correlations are greater than AVE for all constructs for medium and large firms.

Table 6: Construct validity for unconstrained multi-group models

	Medium firms			Large firms		
	AVE	CR	β^2, Φ^2	AVE	CR	β^2, Φ^2
Absorptive capability	0.790	0.908	0.303, 0.053	0.636	0.905	0.372, 0.09
Innovative capability	0.644	0.802	0.303, 0.152	0.546	0.759	0.372, 0.09
Performance	0.544	0.775	0.053, 0.152	0.591	0.692	0.09, 0.09

5. CONCLUSION

In the initial model medium and large firms were examined together. Results of structural equation modeling for the full sample show that all paths are significant and in expected direction. Construct validity (convergent and discriminant validity) of a proposed measurement theory is also confirmed. But, considering that the full group model may hide effects specific to the firm's size, multiple group model comparing large and medium-sized firms is examined. Joint unconstrained and constrained models for all groups were estimated, and results have shown that all path estimates for large and medium-sized companies were significant, in expected direction and indicated much similarity in structural relationships as well as factor loadings. But, with the imposed equality constraints, a highly significant increase in chi-square was observed, and other model fit indices were slightly diminished (for the unconstrained and constrained model, respectively). The fit of constrained model was compared with a fit of an unconstrained model using the difference in Chi-square statistics. Difference between Chi-square of unconstrained and constrained multiple group SEM model equals $\Delta\chi^2$ =230.98, with the difference in degrees of freedom of Δdf=29. So, with p less that 0.0001, it can be concluded that difference in factor loadings and path estimates for medium and large firms is extremely statistically significant, i.e. unconstrained multiple group model is accepted. Using absolute and incremental fit indices overall fit of unconstrained multiple group models is confirmed. Indicators of construct validity for the unconstrained multiple group models show that convergent and discriminant validity are also confirmed for both unconstrained multi-group models. According to accepted model, direct effect of absorptive capability on firm's performance is greater than direct effect of innovative capability on firm's performance for medium-sized firms while, for large firms, abovementioned effects are the same. For medium-sized firms, indirect effect of absorptive capability on firm's performance is 0.13 and total effect equals 0.36, while indirect effect of innovative capability on firm's performance is 0.21 and total effect is 0.60. For large companies, indirect effect of absorptive capability on performance is 0.18, and total effect is 0.48, while the effect of innovative capability is the same as the effect of absorptive capability.

REFERENCES

Capon, N., Farley, J.U., Hulbert, J. and Lehmann, D.R. (1992), ″Profiles of product innovators among large US manufacturers″, *Management Science*, Vol. 38, pp. 157–169.

Cohen, M.D. and Levinthal, D.A. (1990), ″Absorptive capacity: a new perspective on learning and innovation, *Administrative Science Quarterly*, Vol. 35, pp. 128-152.

Cudek, R., Du Toit, S. and Sorbom, D. (2001), Structural Equation Modeling: Present and Future, SSI International, Lincolnwood, IL

Deeds, D.L., DeCarolis, D. and Coombs, J. (1999), ″Dynamic capabilities and new product development in high technology ventures: An Empirical analysis of new biotechnology firms″, *Journal of Business Venturing*, Vol. 15, pp. 211-229.

Delmas, M.A. (1999), ″Exposing strategic Assets to Create New Competencies: The Case of Technological Acquisition in the Waste Management Industry in Europe and North America″, *Industrial and Corporate Change*, Vol. 8, No. 4, pp. 635-671.

Drnevich, P.L. and Kriauciunas, A.P. (2011), ″Clarifying the conditions and limits of the contributions of ordinary and dynamic capabilities to relative firm performance″, *Strategic Management Journal*, Vol. 32, pp. 254-279.

George, G. (2005), ″Learning to be capable: patenting and licensing at the Wisconsin Alumni Research Foundation 1925-2002″, *Industrial and Corporate Change*, Vol. 14, no. 1, pp. 119-151.

Hair, J.F., *et al.* (2005), *Multivariate Data Analysis*, Pearson Prentice Hall, New Jersey

Halmi, A. (2003), Multivarijatna analiza u društvenim znanostima, Alinea, Zagreb

Hou, J.J. and Chang, H.J. (2008), ″Exploring the Core Components of Dynamic Capabilities″, http://academic-papers.org/ocs2/session/Papers/A1/1164-2250-1-DR.doc [Accessed 25/01/10]

Mels, G. (2006), *LISREL for Windows: Getting Started Guide*, Scientific Software International, Inc., Lincolnwood, IL

Miller, D. and Friesen, P.H. (1983), ″Strategy-making and environment: The third link″, *Strategic Management Journal*, Vol. 4, Issue 3, pp. 221-235.

Newey, L.R. and Zahra, S.A. (2009), ″The Evolving Firm: How Dynamic and Operating Capabilities Interact to Enable Entrepreneurship″, *British Journal of Management*, Vol. 20, pp. S81-S100.

Petroni, A. (1998), ″The analysis of dynamic capabilities in a competence-oriented organization″, *Technovation*, Vol. 18, No. 3, pp. 179-189.

Powell, T.C. (2001), ″Competitive Advantage: Logical and Philosophical Considerations″, *Strategic Management Journal*, Vol. 22, No. 9, pp. 875-888.

Protogerou, A., Caloghirou, Y. and Lioukas, S. (2008), ″Dynamic Capabilities and Their Indirect Impact on Firm Performance″, *Paper submitted to the DRUID 25th Celebration Conference 2008*

Raykov, T. and Marcoulides, G. (2006), A First Course in Structural Equation Modeling, Lawrence Erlbaum Associates, New Jersey

Salvato, C. (2003), ″The role of micro-strategies in the engineering of firm evolution″, *Journal of Management Studies*, Vol. 40, No. 1, pp. 83–108.

Tripsas, M. (1996), ″Surviving radical technological change through dynamic capabilities: evidence from the typesetter industry″, *Industrial and Corporate Change*, Vol. 6, pp. 341–377.

Wang, C. L. and Ahmed, P. K. (2004), ″The development and validation of the organizational innovativeness construct using confirmatory factor analysis″, *European Journal of Innovation Management*, Vol. 7, No. 4, pp. 303–313.

Wang, C.L. and Ahmed, P. K. (2007), ″Dynamic capabilities: A review and research agenda″, *International Journal of Management Reviews*, Vol. 9, Issue 1, pp. 31-51.

Woiceshyn, J. and Daellenbach, U. (2005), ″Integrative capability and technology adoption: evidence from oil firm″, *Industrial and Corporate Change*, Vol. 14, pp. 307–342.

Zahra, S.A. and George, G. (2002), ″Absorptive capacity: A review, reconceptualization, and extension″, *The Academy of Management Review*, Vol. 27, No. 2, pp. 185-203.