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INTER-FIRM COLLABORATION AND

ELECTRONIC BUSINESS:

EFFECTS ON PROFITABILITY IN FINLAND***

ABSTRACT: This paper studies the joint effects of inter-firm collaboration and electronic business on firm profitability primarily in Finnish manufacturing. It is found that deeper forms of inter-firm collaboration boost financial performance but that high e-business intensity might even strain profitability. Firms that simultaneously have high inter-firm collaboration and e-business intensities as well as use electronic networks for conducting their collaboration are also more profitable. Based on this, two conclusions are drawn. First, suitable e-business practices facilitate inter-firm collaboration. Once in place, inter-firm collaboration tends to be immensely more productive with supporting electronic means. Second, e-business investment has to be accompanied with complementing organizational innovations, in this case a new form of external (and also internal, although not observed directly in the data used) organization of the firm, i.e., inter-firm collaboration.

TIIVISTELMÄ: Tässä paperissa tutkitaan samanaikaisesti yritysten välisen yhteistyön tai verkostoitumisen ja sähköisen liiketoiminnan kannattavuusvaikutuksia lähinnä suomalaisissa teollisuusyrityksissä. Syvemmät yhteistyömuodot näyttävät parantavan niitä harjoittavien yritysten kannattavuutta. Sähköinen liiketoiminta puolestaan näyttäisi jopa laskevan kannattavuutta kuitenkin niin, että yritykset jotka harjoittavat samanaikaisesti laajamittaista yritysten välistä yhteistyötä ja sähköistä liiketoimintaa sekä käyttävät elektronisia tietoverkkoja keskinäisen yhteistyönsä välineenä ovat kannattavampia. Tähän löydökseen perustuen tutkimuksessa tehdään kaksi johtopäätöstä. Ensiksi, tietyt sähköisen liiketoiminnan muodot tukevat yritysten välistä yhteistyötä. Kun nämä elektroniset välineet on otettu käyttöön, ne tehostavat merkittävästi keskinäistä kanssakäymistä. Toiseksi, kannattaviin sähköisen liiketoiminnan investointeihin liittyvät täydentävät organisatoriset innovaatiot, tässä tutkimuksessa siis uudet ulkoiset (ja epäilemättä myös sisäiset, joskaan niitä ei käytetyssä aineistossa havaita suoraan) kanssakäymisen muodot.

INTRODUCTION

Due to increasing technological speed and complexity as well as intensifying global competition, firms are keenly concentrating on their core competences. As a direct consequence, inter-firm collaboration is becoming and increasing important part of firms' business activities. Many previously strategic in-house functions, such as electronics manufacturing, have now been commoditized to the extent that maintaining own capacity hardly seems worthwhile even for relatively large firms.

Nowadays literally any business function can be outsourced. Some firms have done so to the extent the discussion on the hollowness of modern corporations is indeed warranted. The level of commitment in inter-firm collaborative arrangements varies greatly. Most of them are perhaps best likened to market transactions, but deeper forms are also quite prevalent. In an extreme case the interests of parties involved are inseparable; effectively they form a new business entity but technically organizational boundaries still exist.

A well-managed portfolio of collaborative arrangements can be a real and lasting source of competitive advantage, as it makes the firm more flexible and lean as well as puts a more diverse set of resources at its disposal. It is not far-fetched to argue that in the future it might be networks of firms rather than large corporations that compete in the global market place. On the flip side, inter-firm collaboration makes the parties involved inter-dependent and exposes them to new risks. Also in this case the chain is only as strong as its weakest link but, contrary the case of internally management functions, no single party has a direct mechanism to oblige desired behavior.

In this chapter we implicitly focus on vertical inter-firm collaboration, i.e., on connections to up- and downstream industries. This focus is primarily driven by the definitions of the collaboration-related explanatory variables. Horizontal inter-firm collaboration (e.g., strategic alliances) does not typically involve significant goods and/or service flows between the parties involved, as the firms are by definition in the same industry. This is also likely to be the case for diagonal inter-firm collaboration between parties in unrelated industries.

The mushrooming of inter-firm collaboration has in part been driven by rapid advances in information on communication technologies (ICTs). Real-time coordination of geographically and organizationally dispersed business activities has only recently become sufficiently cost effective for a wide range of businesses. On the other hand electronic business (e-business) practices have often followed rather than led the developments, i.e., inter-firm collaboration was becoming increasingly common even before the ICT boom of the 1990s and was not necessarily tied to introductions of new e-business practices. In many cases new electronic tools have nevertheless been welcomed aids in the ongoing collaboration.

Designing e-business practices to suit the needs of a given organization is not a trivial task. The task is immensely more complex when several organizations are involved. Not necessarily coordinated by nevertheless aligned decisions have to be made on, e.g., communications platforms and interfaces as well as on business process reengineering. The collective associated investments are substantial and in considerable part sunk, i.e., unrecoverable if collaboration was to be discontinued. Thus, e-business may be seen as an agitator, enabler, and/or enforcer in inter-firm collaboration.

In what follows, we study inter-firm collaborative arrangements and e-business practices in tandem. We focus on their profitability effects among Finnish business enterprises primarily in manufacturing industries.

LITERATURE

As pointed out by Gulati, Nohria and Zaheer (2000), in the current literature on inter-firm collaboration financial performance considerations are largely ignored. The few studies that do touch upon the issue are not directly comparable and provide mixed evidence. Bastos (2001) finds no conclusive evidence of the performance effects of collaboration. Both Chung and Kim (2003) and Claro, Hagelaar and Omta (2003) suggest that deeper forms of inter-firm collaboration are associated with better performance. Soh (2003) finds that performance improves with the number of repeated partners and relative 'centrality' in the collaborative arrangement.

While macroeconomic effects of ICT (see, e.g., Gordon, 2000; Jorgenson, 2001; Oliner & Sichel, 2000) have perhaps been the most discussed issue in the new economy literature, there is relatively large and growing literature on microeconomic effects as well (reviewed in, e.g., Brynjolfsson & Hitt, 2000; Dedrick, Gurbaxani, & Kraemer, 2003; OECD, 2003). The available firm-level evidence suggests that the performance effects of ICT greatly depend on the implementing firms' ability to reengineer their business processes and introduce complementary organizational innovations. To our knowledge external organizational choices, i.e., inter-firm collaborative agreements, have not been studied in this context.

Articles considering both inter-firm collaboration and e-business are quite rare. Lee and Lim (2003) study the use of electronic data interchange (EDI) and involved firms' partnership attributes. They find that that the extent of EDI integration, exchange, and performance is higher in deeper relationships. Lee, Pak and Lee (2003) contrast basic and collaborative business-to-business (B2B) electronic commerce (e-commerce). In basic B2B e-commerce firms merely computerize commercial transactions. In collaborative B2B e-commerce electronic networks are used to facilitate inter-firm collaboration. The survey findings suggest that the source of performance improvements is not the B2B e-commerce in itself but rather the inter-firm collaboration it enables. Neither of these studies explicitly focuses on the ultimate performance effect from a firm's point of view, i.e., profitability.

We are unaware of any prior studies that would closely resample our work, although the volume and co-existence of inter-firm collaboration and e-business practices clearly calls for such work.

DATA

The stellar economic performance of Finland in recent years is in considerable part attributable to ICT-related developments (Rouvinen & Ylä-Anttila, 2003). These developments were aided by intense intra- and inter-sector interactions which by many studies (see, e.g., EU, 2000; OECD, 1999) are characteristic to the Finnish national innovation system (Georghiou, Smith, Toivanen, & Ylä-Anttila, 2003). Jalava and Pohjola (2002) show that in the aggregate terms Finland is among the leading new economies, i.e., the absolute macroeconomic effects of ICT in the late 1990s were quite similar to those in the United States. As distinct from the U.S. experience, however, the Finnish effects are mostly mediated via ICT provision as opposed to ICT use. Maliranta and Rouvinen (2003a; 2003b) find that the average firm-level effect of ICT in Finland closely corresponds to the mean estimate calculated across available international studies. Thus, Finland should provide an interesting test bed in quantifying the joint effects of inter-firm collaboration and e-business. The context is not entirely unlike in other industrialized countries, although generalizations should be made with caution.

The key sources of information for our study are two rather unique and extensive surveys conducted by the Confederation of Finnish Industry and Employers (TT) in Finland. In spring 2000 the electronic business survey collected quantitative data on the adoption of e-business practices in various corporate functions. The survey was sent to approximately 500 Finnish primarily manufacturing firms and 360 responses were received – together they represent roughly half of Finnish manufacturing in terms of sales volume and employment. In early 2001 the corporate networks survey addressed various aspects of inter-firm collaborative arrangements: how common they are, what are the underlying factors, what kind of problems are associated with it, and what are their effects. The survey form was sent to approximately 700 companies and 363 responses were received – together they represent over half of Finnish manufacturing in terms of sales volume and employment.

While both surveys have been conducted only once, we do observe e-business expenditure from 1998 to 2000 thanks to some retrospective questions in the survey. After three-way matching of the two surveys and Balance Consulting's financial statement database, we are left with a three-year balanced quasi panel of 107 firms (82 in manufacturing) and 321 observations.[1]

Our dependent variable is return on assets (ROA), ratio of net income to total assets, which is a common measure of firm performance. It is calculate as follows:

$$ROA = \frac{\text{pre-tax profits before extraord. items \& appropriations + financial expenses}}{\text{total assets}}. \quad (1)$$

ROA tells how well the firm uses its assets to produce income. The ratio tends to be high for firms having high sales margins and for firms generating high sales volume relative to their assets. ROA is a relatively standard measure of firm performance (W. P. Barnett, Greve, & Park, 1994).

The sample mean of ROA is 12.7%, which is quite high but not unusual in economic upturns. It seems to be reducing over time: year 1998 mean is 13.7% whereas year 2000 mean drops to 11.6%. For roughly one in tenth of observations ROA is negative. Figure 1 shows a histogram of ROA observations.

Figure 1. A histogram of the return on assets (ROA) observations (with an overlay of a normal distr.).
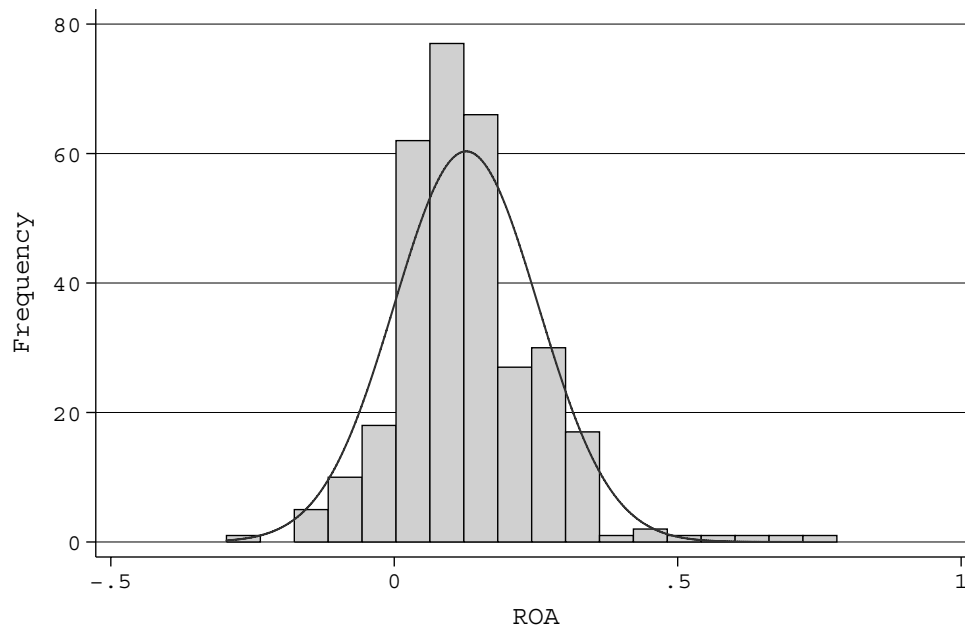
Note: ROA is a continuous variable. The number of bins (k) in the histogram determined according to the following standard formula (Stata version 8): $k = \min\{\sqrt{N}, 10\ln(N)/\ln(10)\}$, where N is the number of observations.

The control variables include (natural logarithm of) sales (in millions of euros and year 2000 prices), firm age (years elapsed since the firm was established), a dummy for the firm being established recently (less than three years ago), sales growth from the previous year as well as industry (with other industries as the reference group)[2] and time (with year 2000 as the reference) dummies.

Three indicators of inter-firm collaboration are considered: its extent – the inter-firm collaboration intensity (the share of sales generated via inter-firm collaborative agreements),[3] its depth – the share of long-term commitments (the share of partnership-like long-term networking commitments),[4] and its organization – a dummy of having a mutual written collaboration strategy.[5]

Three measures of e-business practices are included: e-business intensity (the ratio of e-business investments to sales),[6] a dummy for having online sales,[7] and a dummy for using electronic networks for inter-firm collaboration (e-collaboration).[8]

The final variable, and perhaps the one of greatest interest, is a three-way interaction term of the inter-firm collaboration intensity, the e-business intensity, and the e-collaboration dummy.

Table 1 shows basic descriptive statistics of our sample data. Year 2000 sales of the firms in the sample range from 1.3 million to 13 billion euros with a mean of a good three hundred million euros. The sample firms are on average over a quarter of a century old; only 1.6% of the sample firms are recently established. At almost fifteen per cent, the mean sales growth of the sample firms is quite brisk in the observation period.

Table 1. Descriptive statistics of the sample (107 firms, 321 observations).

Variable	Description	Mean	St. dev.	Min.	Max.
Firm	Firm identification code			1	107
Year	Observation year			1998	2000
Profitability	Return on assets, ROA	0.127	0.127	-0.296	0.721
Sales	Log of net sales in mill. € & 2000 p.	3.263	1.804	0.038	9.531
Age	Years elapsed since founded	25.841	33.678	0	164
New	Dummy for new firms, <3 years old	0.016	0.124	0	1
Growth	Sales growth	0.148	0.560	-0.649	9.134
Collaboration	Inter-firm collaboration intensity	0.328	0.364	0	1
Partnership	Share of long-term commitments	0.286	0.314	0	1
Strategy	Dummy for having a written strategy	0.570	0.496	0	1
e-business	e-business intensity	0.005	0.014	0	0.110
e-commerce	Dummy for having online sales	0.280	0.450	0	1
e-collaboration	Dummy for e-collaboration	0.785	0.411	0	1
Interaction	Collaboration * e-business * e-collab.	0.001	0.004	0	0.044
Ind., Food	Ind. dummy: Foodstuffs, bev., tobacco	0.056	0.230	0	1
Ind., Textiles	Ind. dummy: textiles, apparel, leather	0.093	0.292	0	1
Ind., Paper etc.	Ind. dummy: Pulp, paper, publishing	0.112	0.316	0	1
Ind., Chemical	Ind. dummy: Chemicals	0.112	0.316	0	1
Ind., Minerals	Ind. dummy: Metals, non-met. miner.	0.075	0.263	0	1
Ind., Met. prod.	Ind. dummy: Metal products	0.084	0.278	0	1
Ind., Machinery	Ind. dummy: Machinery, transp. equip.	0.159	0.366	0	1
Ind., Electrical	Ind. dummy: electrical & electronic eq.	0.056	0.230	0	1
Ind., Constr.	Ind. dummy: construction	0.056	0.230	0	1
Ind., Biz serv.	Ind. dummy: IT & other business serv.	0.121	0.327	0	1
Year, 1998	Time dummy, year 1998	0.333	0.472	0	1
Year, 1999	Time dummy, year 1999	0.333	0.472	0	1

Note: See Endnotes 3–8 for further details on the inter-firm collaboration and e-business variables.

On average nearly one third of the firm's sales is generated via inter-firm collaborative agreements. A more detailed look reveals that the distribution is quite skewed: almost one third of the firms have no sales of this type; for roughly one tenth of the firms all sales are generated via such agreements. The mean share of partnership(s) in inter-firm collaboration is over one fourth but again the distribution is skewed: for close to forty per cent of the firms this share is zero; the remaining observations are relatively evenly distributed across the range. Nearly sixty per cent of the firms report that written rules of engagement exist for one or more of their inter-firm collaborative agreements.

E-business investments are on average about half a per cent of sales. One fifth of the sample has not made any e-business investments. About one fourth of the samples firms have online sales. Over three fourths exploit electronic networks in their collaboration with other firms.

Foodstuffs, beverages, and tobacco is the smallest industry in our sample, accounting for less than six per cent of the observations. Machinery and transport equipment is the biggest industry in our sample, accounting for sixteen per cent of our sample.

Table 2 shows pairwise correlations of the variables. The inter-firm collaboration intensity and partnerships are positively associated with growth. Deeper forms of collaboration are associated with better profitability. E-business intensity tends to be higher among smaller firms.

Table 2. Pairwise correlations of variables.

	Profitability	Sales	Age	New	Growth	Collaboration	Partnership	Strategy	e-business	e-commerce	e-collaboration	Interaction
Profitability	1											
Sales	0.05	1										
Age	0.02	0.06	1									
New	-0.08	0.05	-0.09	1								
Growth	0.18*	0.05	-0.07	-0.01	1							
Collaboration	0.03	0.07	-0.13*	0.02	0.12*	1						
Partnership	0.15*	0.07	0.00	-0.07	0.12*	0.33*	1					
Strategy	-0.02	0.05	0.09	0.01	-0.05	0.37*	0.08	1				
e-business	-0.03	-0.27*	-0.09	0.00	-0.01	-0.01	0.00	0.02	1			
e-commerce	-0.03	0.24*	0.12*	-0.02	-0.01	0.05	0.312*	0.08	-0.04	1		
e-collaboration	0.03	-0.01	0.05	-0.12*	0.03	0.05	0.18*	0.10	-0.07	0.28*	1	
Interaction	0.04	-0.21*	-0.08	-0.01	-0.01	0.22*	0.01	0.20*	0.60*	0.00	0.16*	1

Note: Star (*) indicates the statistical significance of the pairwise correlation at 5% level.

The 1998–2000 period under consideration here is quite exceptional in many respects. We control for symmetric aggregated shocks by including time dummies in our regression. While this alleviates the problem considerably, it does not completely remove it.

As our data is derived by matching three sources of data that are not even initially completely random, obviously our sample is somewhat selected. It has a bias towards larger firms. The sample firms represent one third of Finnish manufacturing sales and less than one per cent of sales in Finnish construction and services in year 2000.

ANALYSIS

Figure 2 shows our stylized research model. It is hypothesized that inter-firm collaboration and e-business practices brings about organizational and operative leanness and effectiveness among the involved firms, especially if the two co-exist and interact. They in turn contribute to better performance.

Figure 2. Stylized research model.
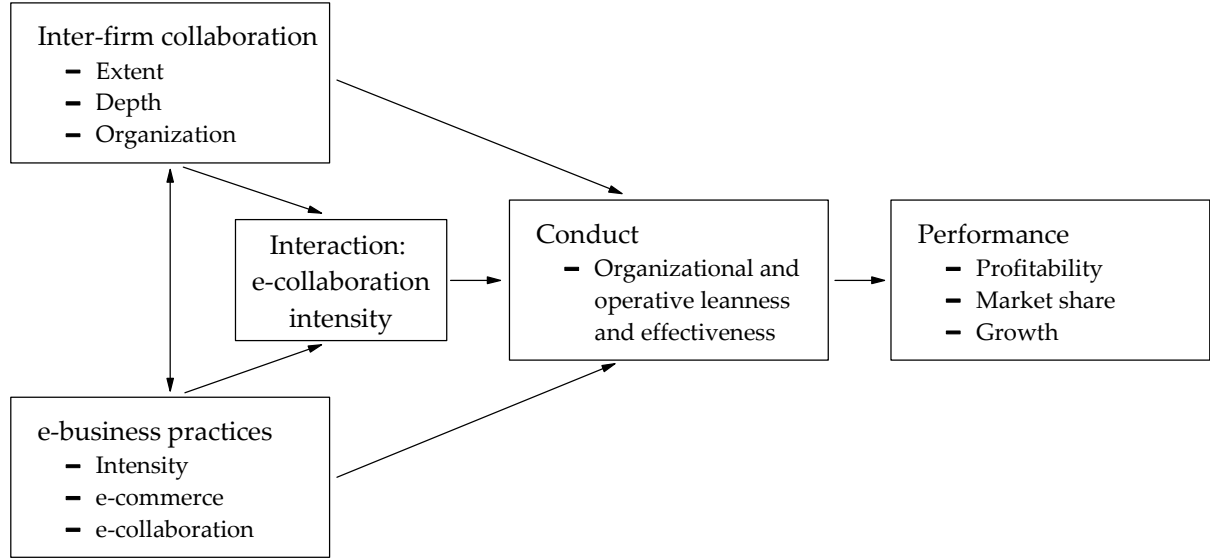
We operationalize the above model by defining the following empirical specification for firm i at time t:

$$
\begin{aligned}
\text{Profitability}_{i,t} = {}& \beta_0 \, \text{Constant} \\
& + \beta_1 \, \text{Sales}_{i,t} + \beta_2 \, \text{New}_{i,t} + \beta_1 \, \text{Age}_{i,t} + \beta_1 \, \text{Growth}_{i,t} \\
& + \beta_{5-14} \, \text{Industry}_i + \beta_{15-16} \, \text{Year}_t \\
& + \beta_{17} \, \text{Collaboration}_i + \beta_{18} \, \text{Partnership}_i + \beta_{19} \, \text{Strategy}_i \\
& + \beta_{20} \, \text{e-business}_{i,t} + \beta_{21} \, \text{e-commerce}_i + \beta_{22} \, \text{e-collaboration}_i \\
& + \beta_{23} \, \text{Interaction}_{i,t} + \varepsilon_{i,t}
\end{aligned}
\tag{2}
$$

where ε is the error term. We use fully robust pooled ordinary least squares (OLS) estimator to derive our core results. Fully robust refers to the fact that we employ White (1980) heteroscedasticity consistent standard errors and also allow for the dependence (autocorrelation) of observations across t. Thus, the measurement of standard errors is robust as long as i s are independently distributed (for discussion see Stata, 2001, section 23.11). We will also consider other estimators in order to study the sensitivity of our results.

RESULTS

Table 3 presents our core results. As can be seen, we do not find evidence for size (Sales) or growth effects. Understandably recently established firms (New) tend to be less profitable. Otherwise firm age does not have an effect on profitability.

Profitability seems to be higher in the chemicals industry (Ind., Chemical), construction (Ind., Constr.), and business services (Ind., Biz serv.). There is some indication that profitability is also higher in minerals and metals (Ind., Minerals) as well as in electrical and electronic industries (Ind., Electrical), although they just miss the mark of being significant at ten per cent level. Time dummies reflect the trend of the dependent variable already discussed above.

Table 3. Estimation of the profitability model (dependent variable: ROA) – pooled OLS with fully robust standard errors.

Constant	0.011	Ind., Food	-0.039
	(0.057)		(0.055)
Sales	0.007	Ind., Textiles	0.048
	(0.010)		(0.048)
New	-0.109**	Ind., Paper etc.	0.051
	(0.047)		(0.049)
Age	0.000	Ind., Chemical	0.109*
	(0.000)		(0.058)
Growth	0.022	Ind., Minerals	0.081
	(0.021)		(0.053)
Collaboration	-0.027	Ind., Met. prod.	0.037
	(0.032)		(0.056)
Partnership	0.085*	Ind., Machinery	0.043
	(0.044)		(0.051)
Strategy	-0.009	Ind., Electrical	0.134
	(0.021)		(0.083)
e-business	-1.359*	Ind., Constr.	0.116*
	(0.762)		(0.059)
e-collaboration	-0.001	Ind., Biz serv.	0.128*
	(0.028)		(0.065)
e-commerce	-0.020	Year, 1998	0.024*
	(0.021)		(0.013)
Interaction	3.200	Year, 1999	0.015
	(2.071)		(0.010)
Observations		321	
R-squared		0.20	

Note: ***, ***, and * respectively indicate significance at 1, 5, and 10 % level. Standard errors in parentheses.

The extent of inter-firm collaboration per se does not have a statistically significant effect on productivity. In fact the coefficient estimate itself is negative, although no conclusion can be drawn on that due to the rather large standard error. The depth of the collaboration (Partnership) has, however, a large positive effect on profitability (the exact significance level is 5.5%). Having explicit 'rules of engagement' (Strategy) does not have an effect on profitability.

High e-business intensity strains profitability. In fact the coefficient estimate suggests that in a typical case e-business investments are wasted, i.e., they reduce profits by roughly the amount of invested. Having online sales (e-commerce) or using electronic networks for inter-firm collaboration (e-collaboration) do not contribute to profitability.

Recall that the interaction term is, first, non-zero only for firms using electronic networks for inter-firm collaboration, and second, the highest for firms that are intensively engaged in both inter-firm collaboration and e-business. Thus is should proxy quite well the use of e-business practices in inter-firm collaboration, although this is not observed directly. Also note that any problems with this proxy will bias us against finding any significant results. Somewhat disappointingly, the interaction terms fails marginally to be significant at ten per cent level.

In the following few sections we will discuss the robustness of the above findings. We consider the roles of time dimension, firm effects, and outliers.

TIME DIMENSIONS AND FIRM EFFECTS

As discussed above, we have a quasi panel at our disposal, i.e., some variables are not observed across time. An alternative approach would have been to estimate the model with cross-sectional data, although some information would have been lost. In the four leftmost columns of Table 4 we derive the results for each of the years as well as for the average of the annual observations (Between Estimator).

Table 4. Estimations of the profitability model for years 1998, 1999, and 2000 (robust OLS) as well as the between and within estimates.

Dependent variable: Profitability (ROA)	Rob. OLS Year 1998	Rob. OLS Year 1999	Rob. OLS Year 2000	Between Estimator	Within Estimator
Constant	0.059	0.004	0.004	0.020	0.043
	(0.080)	(0.057)	(0.064)	(0.050)	(0.299)
Sales	0.007	0.008	0.008	0.009	0.063**
	(0.010)	(0.010)	(0.012)	(0.007)	(0.028)
New	-0.112**	-0.188***	0.000	-0.309**	0.067
	(0.053)	(0.037)	0.000	(0.132)	(0.041)
Age	0.000	0.001*	0.001**	0.000	-0.005
	(0.000)	(0.000)	(0.000)	(0.000)	(0.011)
Growth	0.011	0.208***	0.010	0.060	0.006
	(0.013)	(0.059)	(0.079)	(0.038)	(0.008)
Industry dummies	Yes	Yes	Yes	Yes	No
Time dummies	No	No	No	No	Yes
Collaboration	-0.030	-0.017	-0.021	-0.024	
	(0.040)	(0.036)	(0.033)	(0.037)	
Partnership	0.068	0.094**	0.067	0.075*	
	(0.053)	(0.047)	(0.047)	(0.040)	
Strategy	-0.012	-0.014	0.000	-0.002	
	(0.026)	(0.023)	(0.023)	(0.026)	
e-business	-1.989	-0.170	-1.218	-0.280	-7.203***
	(1.401)	(0.737)	(0.876)	(1.225)	(0.946)
e-collaboration	-0.011	-0.001	0.020		
	(0.039)	(0.028)	(0.036)	(0.029)	
e-commerce	-0.012	-0.029	-0.022	-0.019	
	(0.026)	(0.026)	(0.024)	(0.027)	
Interaction	4.224	-0.708	3.926	1.497	17.107***
	(4.089)	(3.480)	(2.775)	(3.532)	(3.567)
Observations	107	107	107	107	321
R-squared	0.23	0.40	0.19	0.28	0.26

Note: Rob. refers to White (1980) heteroscedasticity consistency. ***, ***, and * indicate significance at 1, 5, and 10 % level. Standard errors in parentheses. To conserve space, industry dummies are included (Yes) but not reported or are not estimable (No).

The results in the above section are consistent in large samples with relatively weak set of assumptions (see, e.g., Wooldridge, 2002, sections 7.8.1–3). It is nevertheless true that pooled OLS is biased and inconsistent if the firm effect is correlated with any of the explanatory variables in Equation (2). In the rightmost column of Table 4 the fixed-effects or within estimator (also known as the least squares dummy variable or the covariance estimator) is used to remove the firm effects.

Table 4 largely confirms the findings of the results section. Partnership is (close to being) significant if estimable. Many coefficients are not estimable with the within estimator, but the results nevertheless show, that the findings on the effects of e-business intensity and its interaction with respect to inter-firm collaboration are not driven by unobserved firm heterogeneity.

OUTLIERS

It is not unusual in regression analysis that the findings are driven by a few extreme observations. We study this possibility by considering two alternative ways of dealing with the outliers: we employ an outlier robust OLS estimator (as suggested in Li (1985); technical details discussed in Hamilton (1991)) and alternatively winsorize our data, i.e., for some variables replace the lowest and/or highest (as indicated in Table 5) one per cent of the variable values by the next value counting inwards from the extremes (V. Barnett & Lewis, 1994).

Table 5. Estimations studying the role of outliers.

Dependent variable: Profitability (ROA)	OLS Outlier rob.	Dependent var.: ROA (Lowest & highest 1% winsorized)	OLS Fully rob.
Constant	0.035	Constant	0.022
	(0.029)		(0.051)
Sales	-0.003	Sales (Lowest & highest 1% w.)	0.003
	(0.004)		(0.008)
New	-0.093*	New	-0.104**
	(0.048)		(0.049)
Age	0.000**	Age (Highest 1% winsorized)	0.000
	(0.000)		(0.000)
Growth	0.104***	Growth (Lowest & highest 1% w.)	0.132***
	(0.025)		(0.044)
Industry dummies	Yes	Industry dummies	Yes
Time dummies	Yes	Time dummies	Yes
Collaboration	-0.010	Collaboration	-0.025
	(0.020)		(0.029)
Partnership	0.061***	Partnership	0.076*
	(0.022)		(0.039)
Strategy	0.009	Strategy	-0.007
	(0.014)		(0.019)
e-business	-1.508**	e-business (Highest 1% w.)	-1.428*
	(0.614)		(0.736)
e-collaboration	0.012	e-collaboration	-0.003
	(0.016)		(0.025)
e-commerce	-0.033**	e-commerce	-0.023
	(0.015)		(0.020)
Interaction	2.409	Interaction (Highest 1% winsorized)	4.655*
	(1.841)		(2.694)
Observations	320	Observations	321
R-squared	0.23	R-squared	0.25

Note: ***, ***, and * respectively indicate significance at 1, 5, and 10 % level. Standard errors in parentheses.

As can be seen in Table 5, accounting for outliers seems to strengthen the findings in the core results section. Also the interaction term is statistically significant in the winsorized case (significant at 20% level with the outlier robust estimator).

CONCLUSION

Economic theory suggests that in the presence of free entry and exit super-normal profits are unlikely to occur unless there are firm-specific assets or resources that are not generally and widely available. Thus, it is hardly surprising that 'standard' inter-firm collaboration or e-business investment does not seem to contribute to profitability. Specific dimensions of either one or a unique combination of the two can nevertheless be a source of sustained competitive advantage.

While inter-firm collaboration as such does not boost profitability, deeper forms of collaboration or partnerships do. One interpretation of this finding is that only after the parties involved are committed to the collaboration are they willing to take the risk of reengineering their internal and external business processes to exploit the ongoing collaboration to the fullest. Without such reengineering, some of the potential benefits are foregone. It seems that only partnerships are win-win situations, where the fruits of the collaboration are justly distributed, in which case the relative centrality in the collaborative network looses some of its meaning (cf. Soh, 2003). There is also a more practical explanation, although its financial significance remains to be evaluated: a long-term commitment simply economizes on transactions costs among the collaborating parties as contracts have to be negotiated less frequently. In any case it matters a great deal in what spirit the collaboration is being conducted. Obviously forming and maintaining fruitful partnerships is not easy. Indeed, as suggested by our data, inter-firm collaboration is quite prevalent but deeper forms are considerably less so.

Our results suggest that high e-business intensity might even strain profitability. Admittedly, however, we are unable to study the adjustment process associated with e-investments due to our short time span. Massive e-business investment took place in the late 1990s but its effects are not necessarily unveiled yet. We have anecdotal evidence that the lags from e-investment to its full effects might be considerable. Cisco Systems Inc. CEO John T. Chambers has argued that "… the greatest payoff doesn't come until seven to nine years after an [e-business] investment is made." (Business Week, 17 Feb. 2003, p. 45). Brynjolfsson and Hitt (2002) indirectly suggest that the lag is from three to seven years. With such lags we would have observed only the immediate negative effect of e-investments in our analysis. In hindsight it can nevertheless be said that some e-investments of the late 1990s are doomed to be unprofitable but perhaps to a lesser extent among established manufacturing firms – as our descriptive statistics indicate, even in the heydays of the new economy e-investment remained on average relatively modest among the sample firms.

Our results confirm that the heart of the matter lies in having a suitable mix of inter-firm collaboration and e-business practices. Firms that simultaneously have high inter-firm collaboration and e-business intensities as well as use electronic networks for conducting their collaboration are also

more profitable. We interpret this as a sign of two things. First, suitable e-business practices facilitate inter-firm collaboration. Once in place, inter-firm collaboration can be immensely more productive with supporting electronic means. Second, e-business investment has to be accompanied with complementing organizational innovations, in this case a new form of external (and undoubtedly also internal, although we do not observed it directly) organization of the firm, i.e., collaboration.

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ENDNOTES

[1] All inter-firm collaboration and most e-business variables are not observed across time.

[2] The specified industries comprise of the following TOL95 industrial classification groups: Food (foodstuffs, beverages, tobacco -- 15, 16); Textiles (textiles, apparel, leather, footwear – 17, 18, 19); Paper etc. (wood and wood products, pulp and paper, publishing and printing – 20, 21, 22); Chemical (coke and nuclear fuel, chemicals, rubber and plastics – 23, 24, 25); Minerals (non-metallic minerals and basic metals – 26, 27); Metal products (fabricated metal products – 28); Machinery (machinery and equipment, transport equipment – 29, 34, 35); Electrical (electrical equipment and machinery, communications equipment, instruments – 30, 31, 32, 33); Construction (45); Business services (computer and related activities, other business service activities – 72, 74). The remaining observations (less than one fifth of the total) fall into the control group.

[3] Section 5 of the corporate networks survey inquires about the scope and depth of inter-firm collaboration. The preceding section 4 asks about the firm's relative position in its collaborative network. Subsection 5.1 includes two questions, one specific to the firm's relative position defined in Section 4 and one referring to other types of inter-firm collaboration. As we want to abstract somewhat from the fine points of networking and discuss inter-firm collaboration in general, we combine the answers to the two questions. Thus, our measure is effectively the firm's self-reported perception on the following question (divided by one hundred): what percentage of your firm's productive turnover is related to inter-firm collaboration?

[4] Subsection 5.2. of the corporate networks survey concerns the composition of inter-firm collaboration by type of contract. The firm is asked to report the distribution of its inter-firm collaboration -related sales across five categories: (a) partnership, (b) annual, (c) project, (d) one-off, and (e) other types of contracts. Partnerships are understood as long-term companionships that both parties are committed to. Our measure is the firm's self-reported perception on the following question (divided by one hundred): what percentage of your firm's inter-firm collaboration -related sales is derived via contract(s) best characterized as partnerships?

[5] Section 8 of the corporate networks survey concerns the operating principles of inter-firm collaboration. It is, among other things, inquired, whether the firm has explicit written contract(s) concerning the strategy of its bi-/multilateral inter-firm collaboration. Our measure is the firm's self-reported perception on the following question: Does your firm have written contract(s) on the operating principles of inter-firm collaboration in the following categories: strategy? (Yes or No).

[6] Adopted from section 3 of the e-business survey inquiring on the firm's e-business investments (defined to included hardware, software, training, acquired services, and personnel expenditures) for various years.

[7] Section 1 of the e-business survey concerns the use of electronic business practices across various business functions. Section 1.e concerns the sales of own products. Our measure is the firm's self-reported perception on the following question: What is your estimate on the percentage share of electronic business practices in the following functions: sales of own products? (Please check one of the following categories: do not know, 0%, under 2%, 2–5%, 5–10%, 10–30%, over 30%). The firm is interpreted to have online sales, if one of the following categories is chosen: 2–5%, 5–10%, 10–30%, or over 30%.

[8] Section 1.f of the e-business survey concerns information transfer(s) between collaborating parties. Our measure is the firm's self-reported perception on the following question: What is your estimate on the percentage share of electronic business practices in the following functions: information transfer(s) between collaborating parties? (Please check one of the following categories: do not know, 0%, under 2%, 2–5%, 5–10%, 10–30%, over 30%). The firm is interpreted to use electronic networks for inter-firm cooperation, if one of the following categories is chosen: 2–5%, 5–10%, 10–30%, or over 30%.

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