Using Software Stacks to Explain Complementarities: The Case of Mergers and Acquisitions in the Software Industry

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Using Software Stacks to Explain Complementarities: The Case of Mergers and Acquisitions in the Software Industry

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Abstract

The existence of product complementarities is especially relevant in network-type industries, such as information technology and communications, where systems of complementary components made by different manufacturers have to be assembled. Relying on the characteristics of software markets and drawing on the economic theory of complementarity, this paper investigates how complementarity creates value in M&As between software companies.

We empirically validate the software “stack”. In a sample of Mergers and Acquisitions, in which either the acquirer or the target is a software firm, we find values of abnormal returns consistent with previous results. However, when we introduce the concept of stack, we find an inverse curvilinear relationship between abnormal returns and the distance between acquirers and targets in various layers of the stack.

1. Introduction

Over the last five years, the software industry has seen a large number of Mergers and Acquisitions (M&As). Some analysts see the recent spate of takeover activity as marking the onset of an era of consolidation within a maturing industry. Perhaps the most important reason why software companies merge is to achieve higher rates of growth. In the 1990s companies were showing high growth rates, but the economic slowdown and the existence of too many software companies dramatically cut growth. One of the ways, and probably the quickest one, that companies can use to grow, is by acquiring other software firms. However, the realization of value through mergers in software markets is not straightforward.

Software markets present special dynamics that distinguish them from conventional markets. Very often, mergers between similar companies are not successful, at least in the short term. M&As add value when firms correctly explore opportunities by taking into consideration the characteristics of the software industry.
This study explores value creation using M&As and shows how companies can use software stacks as a way to create value. Using the three-layer stack, defined by the layers hardware, software and services, we find that mergers in which acquirers and targets produce in the same layer of the stack earn smaller abnormal returns than acquisitions in which acquirers and targets produce in different layers. However, the results are not statistically robust. When we extend the study to a more detailed definition of the stack, the significance of the results is improved. These results empirically validate the existence of the stack and show that complementarity is a source of value creation in M&As between software companies.

2. Characteristics of software markets

Software markets are different from conventional markets. The existence of direct externalities -- the idea that a product’s valuation is higher for larger installed bases of consumers -- is a reason for managers to place significant effort in expanding market shares.

In network-type industries, two or more components made by different manufacturers using different technologies may have to be used together, and systems have to be interoperable. Network effects across markets result in higher valuation for products with larger complementary markets and create incentives for producers of a particular good to enter the markets for complements.

Compatibility is also an important issue to the users. The number of network users reflects long-term market stability and consumers prefer firms with large installed bases. An established standard provides access to a larger network composed of firms complying with that standard. Consequently, standards are a source of network externalities [1]. Competition in these markets differs significantly from competition in conventional markets. An
understanding of the factors that may influence market dominance is critical for competition in markets with network externalities. It can be very difficult for new companies to compete with established competitors in the presence of network externalities [2]. When consumers place a great value on the size of the installed base, the “best” product or service does not always win [3].

There are many ways in which firms can explore complementarities in network systems to create competitive advantages and value. Companies that produce highly complementary components may want to integrate if customers value a more reliable systems integration supplied by a single provider. The bundling of different application categories into products, by promoting the standardization of commands and functional interoperability, allow combined providers to offer a better service to existing customers and to attract new customers that see value in the integration of compatible products. Many markets that are subject to network externalities are also characterized by having multiple sides. In multisided markets, consumers benefit not from using both complementary products separately but from interacting with consumers of complementary products through a common platform. Providing both components may offer opportunities for the firm to enhance exchange benefits.

Companies can use either their installed base, or the installed base of complementary components, to leverage and promote growth. Companies may acquire with the intent of quickly gaining market share. In some cases the purpose is to acquire the installed base of an old technology and then gradually replace it with the company's own technology. In other cases, companies make acquisitions in a complementary market with the purpose of foreclosing competitors in that market. The 'winner takes all' nature of software economics has
given firms that have achieved major platform status massive profit pools from which to invest in adjacent software categories.

However, companies may face difficulties with the technical integration of the software products. In theory they have a completely integrated product the day after the announcement of a merger, but in practice integration may take much longer. In some cases some products may be abandoned. If the product complementarity is a motive for the acquisition but companies fail to integrate products, the potential synergies are not realized and underperformance will occur when compared with the price paid for the acquisition.

3. Role of complementarities

In network-type industries, particularly industries in information technology, decision-making and strategy are shaped by the existence of complementarities and network effects.

The theoretical foundations of this paper are the economic theory of complementarities and the literature on network economics. The economic theory of complementarities focuses on the super-additive value of combining activities. Activities are complements if increasing (doing more of) one of them increases the returns of (doing more of) the other. This means that marginal returns in one activity vary with the level of variables in the other activity, for example prices. Milgrom and Roberts [4] formalize this idea in which “the whole is more than the sum of the parts”, i.e., the returns obtained from combining the activities are greater than the sum of the returns of both activities in isolation. In their paper, they explain how the concept of network externality fits this definition of complementarity and illustrate this with the example that “(…) the gains for computer users from focusing on just one or two standards
is that it eases the development of complementary products including both software (…) and hardware.”

Foundational theoretical models where products and services are subject to network externalities were introduced in Farrell and Saloner [5] and Katz and Shapiro [6]. Network externalities are defined by the benefits of having a larger number of consumers purchasing compatible products. Direct network externalities stem from the benefits from having a large installed base where standardized products provide access to larger physical networks. This direct effect is relevant, for example, in applications software such as word-processing and spreadsheets, where users have the need to share files. Another benefit from a larger installed base is the indirect effect of an enhanced provision of complementary goods. This effect, in which complementary products benefit from the installed base of the complement, is usually referred as indirect network externalities. One of the benefits of having a large installed base in hardware is the incentive for stronger competition in the complementary market for software. This paper focuses on indirect network externalities. Furthermore, this paper builds on the afore-mentioned literature on complementarity to investigate its role in M&As between producers of complementary components of network systems. Formally, the hypothesis to be tested is:

*Hypothesis: The existence of complementary network effects between acquirers and targets is a source of value creation in Mergers and Acquisitions.*

There is no generally accepted empirical measure of complementarity. Current measures of complementarity are either difficult to operationalize, or imprecise in defining the value of product complementarity, or require information for which data is not readily available.
Sudaram, John and John [7] operationalize the concept of strategic substitutes and complements in a competitive interactions context – they study announcement effects of R&D spending. The concept of strategic substitutes and complements was introduced by Bulow, Geanakoplos and Klemperer [8]. The difference between strategic and conventional complements is that a change in a strategic variable (price in price competition, quantity in quantity competition, advertising, etc.) will raise the competitor’s marginal profits instead of total profits. To implement the idea of strategic substitutes and complements empirically, Sudaram, John and John (1996) propose a measure obtained by computing the coefficient of correlation between a firm’s marginal profits (change of the profits relative to changes in own output) and the change in the competitor’s output. When this measure is positive (negative) firms compete in strategic complements (substitutes). However, the application of this methodology will not distinguish between the value of realizing direct externalities from the increase in the consumer base and the value of product complementarity.

Some other studies use detailed data about software markets to study the effect of product complementarity. For example, Cottrell and Koput [9] estimate the effects of software provision on the valuation of hardware in the early microcomputer industry and conclude that there is a positive relationship between software variety and price. Network externalities explain the dependency of the price of a hardware platform on the size of the installed based and on the variety of software available. Cottrell and Nault (2004) find little evidence of benefits from economies of scope in production, but conclude that there are benefits from economies of scope in consumption. Their study is focused on the variety and integration of application categories into products. Gallaugher and Wang [10] empirically test several key factors influencing software pricing, including network externalities and cross-market
complementarities. In a study applied to web servers, they find a positive relationship between market share and price and that firms with a larger share of the browser market enjoy higher server prices. They conclude that firms that are able to capture market share for one product enjoy benefits in terms of market share and price for the complement. In a study applied to computer spreadsheets, Brynjolfsson and Kemerer [11] find that prices significantly increase with the installed consumer base and products that adhere to a dominant standard exhibit higher prices. This study is related to, and empirically tests, some of the predictions of models that study the internalization of complementarity effects and network externalities in investments in networks.

Several papers study the effect of integration between complements, starting with Cournot (1838). There are a vast number of papers that study the effects of integration or specialization when there is the possibility of interoperability and standardization [12-14]. In general, the results suggest that consumers prefer to purchase from separate producers if there is standardization and from integrated producers if not.

3.1. Constructing a measure of complementarity

We propose a measure of complementarity between two firms based on the structure of the software stack. This measure takes into account the positioning of companies in different segments of the software industry. The industrial organization of the software industry can be structured according to an approach imported from the software architecture, commonly designated as “the stack”.
The software stack

One of the most common approaches in software architecture is a layered view of the architecture. Layering reflects a division of the software into units, generally called virtual machines, where each unit provides a cohesive set of services that other software programs can utilize without knowing how these services were implemented [15]. These units, or layers, should interact with each other according to a strict ordering relation. These relations are usually represented as a stack, in which each layer is allowed to use only the nearest layer or any layer further apart, but higher layers can only use the facilities of lower layers. Lower layers are usually built using knowledge of the computers, communications channels, distribution mechanisms, process dispatchers, etc, and are independent of the applications that may run on them. Higher layers use the facilities of lower layers and are more independent of the hardware in which they work, because the existence of lower layers permit them to do so. This means that higher layers don’t have to change if there is a change on the computing platform or environment. A change in a lower layer that does not affect the interface used will require no change in higher layers. Also, a change in a higher layer that does not change the facilities required will not affect lower layers.

Software developers focus on one or a few layers of the stack and rely on other developers to provide the requisite functionality in other layers. Software architecture of a program or computing system provides a description of the system as a sum of parts, or sub-systems, and how those parts relate and interoperate with each other. These sub-systems carry out some cohesive set of functionality that can be executed independently and are loosely coupled to the rest of the system.
The software activity as a whole can be organized in a similar way. The software stack divides the software activity into layers that are complementary to each other, as depicted in Figure 1. As explained by Lou Gerstner, former CEO of IBM, most companies specialize on one or few layers and rely on other companies to offer the complementary components [16]. Each of these components is layered above the other, and communicates through more or less standard interfaces, with closer layers being more related to each other than layers that are further apart on the stack.

This organization of the software industry has important implications for the structure of the industry competition. Each layer depends on the layers below, that are complementary, and integration requires coordination among suppliers. Competition occurs at each layer, with the suppliers in lower layers trying to provide at that layer for a wider range of suppliers in layers above. This creates some pressure on suppliers within lower layers to integrate with suppliers in higher layers. In software markets, the main underlying factor for success has been the ability of companies to establish platforms with high levels of integration and high associated switching costs for users. Standardization allows competition at the level of the different components of the system. However, dominant firms may have to establish standards and initially engage in standards competition. A new entrant can compete by introducing a new architectural layer that spans two or more previously incompatible dominant architectures [17].

One of the consequences of stacks is that different layers within the stack can develop at different speeds. The details of each layer are hidden from the layers above and below a given layer. Another consequence of stacks within an industry is that different firms can supply different layers of the stack, resulting in divided technical leadership [18]. A third consequence is that customers and firms can experiment with alternative designs at a significantly lower cost.
than they could in the absence of layered modularity. This has been referred to as combinatorial innovation [19]. The idea is that every now and then a set of standardized parts or components comes along, triggering a wave of experimentation by innovators who tinker with the many combinations of these components. The result: a wealth of new systems built on the newly available components or by recombining existing components. Some of these systems are novel even to the designer of the component!

Even though the stack is common knowledge within the software industry and software companies devise their strategies based on the stack, there is little empirical work that proves its existence. We claim that, if the software stack can be the structure of a reliable measure of complementarity between firms in network systems, we can provide evidence on its validity as the structure of the organization of the software industry.

![Diagram of the stack](image)

**Figure 1 – The stack**

*The stack distance index*

We propose a measure of concentration/diversification based on the software stack. This measure is an adaptation of the Herfindahl index and the concentric index, used extensively in
the strategic management literature. The Herfindahl index is generally defined as the sum of
the squared market shares of firms within one industry and measures the degree of
concentration of a specific industry. One of the criticisms leveled on this measure is the
unfavorable weight given to smaller firms. The concentric index is in itself an adaptation of the
Herfindahl index and is widely used to measure relatedness in corporate portfolios of
multibusiness firms or between business units of a firm [20-23]. The concentric index is equal
to the weighted sum of a coefficient that assumes mechanically imposed and pre-established
values according to the relations of the SIC codes of pairs of industries, where the weights are
equal to the product of the percentage of sales of the firm for each of these industries. One of
the major problems associated with the concentric index, the way it is generally constructed, is
that it imposes strong assumptions based on SIC codes. That procedure assumes that industries
are homogenous within each SIC category, and that different levels of SIC codes, at the 2, 3
and 4-digit level, reflect an increasing scale of relatedness. To alleviate this problem, Davis
and Thomas [24] and Robins and Wiersema [23], estimate the coefficient that measures
relatedness.

We define the stack distance index \( STACKD \) as the weighted sum of a coefficient that
represents the distance on the stack between two different layers or industry segments. The
weights are equal to the product of the percentage of sales of each firm in the corresponding
layer. The index is formally computed as:

\[
STACKD = \sum_{i=1}^{L} \sum_{j=1}^{L} P_{ai} P_{ij} d_{ij}
\]

where,

\( STACKD \) denotes stack difference index,
$L$ is the number of layers of the stack,

$P_{Ai}$ is the percentage of sales of the acquirer in layer $i$ of the stack,

$P_{Tj}$ is the percentage of sales of the target in layer $j$ of the stack,

$d_{ij}$ is a coefficient that assumes different values according to the distance on the stack between layer $i$ and layer $j$,

and $\sum_{i=1}^{L} \sum_{j=1}^{L} P_{Ai} P_{Tj} = 1$.

The construction of the $STACKD$ index captures two important features that define the difference between two software companies:

It takes into account the positioning of companies in the different segments of the software industry; and

It considers the spectrum of activities in which both firms are engaged to construct a measure that relates the focus of each company.

As an example, consider the reduced two-layer stack Hardware/Software. Define $d_{ij}$ equal to 0 if industry segments are classified in the same layer of the stack, and equal to 1 if industry segments are classified one layer apart, i.e.,

$$d_{ij} = \begin{cases} 
0 & \text{if } i = j \\
1 & \text{if } i \neq j 
\end{cases}$$

The value of the index is equal to

$$STACKD = P_{Ah} P_{Th} * 0 + P_{Ah} P_{Ts} * 1 + P_{As} P_{Tm} * 1 + P_{As} P_{Ts} * 0$$

$$= P_{Ah} (P_{Th} * 0 + P_{Ts} * 1) + P_{As} (P_{Tm} * 1 + P_{Ts} * 0)$$

where $P_{Ah}, P_{As}$ are the proportion of sales of the acquirer in hardware and software and $P_{Th}, P_{Ts}$ are the proportion of sales of the target in hardware and software.
If both the acquirer and target are exclusively software firms, the value of the index is equal to 0, i.e., the distance between both firms on the stack is 0. If the acquirer is exclusively a software firm and the target is exclusively a hardware firm, the value of the index is 1, i.e., both firms are one layer apart on the stack. If the acquirer is exclusively a software firm, the value of the index increases with the percentage of sales of the target in hardware, i.e., the more hardware the target produces the larger is the distance between the acquirer and target. The way the index is defined, in this particular case, generates values that are between 0 and 1, where 1 is the largest possible distance on the stack between acquirer and target. In general, the value of the index has a minimum equal to the minimum value that $d_{ij}$ assumes, and that corresponds to the cases when $i=j$, and a maximum value equal to the largest $d_{ij}$, which defines the largest distance between two layers of the stack. The $STACKD$ index is simply the weighted average of the distances between the different layers of the stack in which two different companies have activity.

4. **Empirical Design and Methodology**

The objective of the empirical work is to study the effects of concentration/diversification around the layers of the stack in M&As between companies in complementary network systems.

To measure concentration/diversification on the stack, we use either the $STACKD$ index, described in the previous section, or a simpler variation of that index that measures concentration on the same layer. This variation of the index is used when the data available does not provide enough information to allocate firms on a five-layer stack, but allocates instead on a reduced three-layer stack, defined by the layers Hardware, Software and Services.
This measure of concentration is defined as:

\[
\text{Concentration} = P_{AH} P_{TH} + P_{AS} P_{TS} + P_{AS} P_{TSv}
\]

where \( P_{AH}, P_{AS}, P_{TS}, \) are the proportion of sales of the acquirer in hardware, software and services and \( P_{TH}, P_{TS}, P_{TSv} \) are the proportion of sales of the target in hardware, software and services.

To test whether complementary network effects create value in M&As, we study abnormal returns around the announcement dates, in a sample of firms in industries characterized by the existence of network effects. Specifically, we select mergers in which both acquirer and target are mainly information technology firms and at least one of the sides produces software. Sales are obtained for each firm, and allocated through the layers of the stack. The \( \text{STACKD} \) index or the concentration measure is then constructed for each transaction.

We compute abnormal returns for acquirers, targets, and combined acquirer/target firms. The analysis is based mostly on the combined abnormal returns, which incorporate the total effects of the strategic motivations that lead to the merger or acquisition. Combined abnormal returns reflect the changes in value in the resulting merged firm or in the value of portfolios of diversified investors.

According to the theoretic foundations of this paper, the existence of complementarities between acquirers and targets of M&As is a source of value creation. Also, the definition of the software stack implies that there are stronger complementary relations between companies that produce in closer layers of the stack. We investigate if abnormal returns are higher for M&As of companies that have activity classified in closer layers of the stack, when compared with companies that have activities classified in the same layer of the stack or in layers that are further away.
To exclude the affect of firm and transaction characteristics we consider the following control variables:

*Method of payment is cash*

There is strong evidence in the M&As literature that cash transactions earn higher abnormal returns for public firms than other methods of payment, particularly when the payment is made with equity. Travlos [25] and others show that acquisitions of public firms paid for with equity earn lower abnormal returns than acquisitions paid for with cash. Asquith, Bruner and Mullins [26], Huang and Walking [27] and Yook [28] provide evidence that stock deals are associated with significant negative results for acquirers while cash deals are zero or slightly positive. The commonly referred explanation for the different value effects of mergers financed with cash or equity is that the announcement period reaction for the acquirer to a stock-financed transaction represents a combination of a merger or acquisition announcement and an equity issue announcement. Myers and Majluf [29] show that equity issues are a signal that the market is overvaluing a company. Travlos [25] also points out that firms with poor results generally pay with equity.

*Transaction Value*

The size of the transaction is related to the size of the target and the percentage of the company that is acquired. It is expected that abnormal returns increase with the transaction value.

*Percentage of Target Acquired*

There are different implications for M&As with different degrees of integration. The percentage of the target acquired can be a proxy for the degree of integration. Zaheer, Castaner and Sounder [30] argue that the performance of acquisitions is related to appropriately
matching the type of relatedness with the degree of integration. They provide evidence, using a survey study, that business similarity and product complementarity are associated with negative performance when integration is low and become more valuable as the degree of integration increases.

*Acquirer’s Equity Value or Acquirer’s Market Value*

Moeller, Schlingemann and Stulz [31] found that announcement abnormal returns are higher for smaller acquirers, regardless of the form of financing and whether the acquired firm is public or private. One of the reasons associated with this result is that managers of larger firms may be more prone to hubris.

Market Value is defined as the sum of market value of equity, long-term debt, debt in current liabilities, and the liquidating value of preferred stock.

*Acquirer’s Tobin q*

Lang, Stulz and Walking [32] and Servaes [33] found that acquirers with higher Tobin q have higher announcement abnormal returns. They also found that returns are higher when targets have lower q ratios. These results indicate that the value of acquisitions is higher if targets are performing poorly and acquirers are performing well. A low q ratio for the target can also be a sign that the firm is under-priced.

Tobin’s q is defined as the ratio of the value of book assets plus market equity minus book equity to the value of book assets.

*Acquirer’s Leverage*

Maloney, McCormick and Mitchell [34] found that higher leverage bidders have higher abnormal returns. Leverage is calculated as the ratio of the firm’s debt (long-term+short-term+preferred stock) to the firm’s book value of common equity.
Acquirer’s cash-flows

Hartford [35] shows that firms with excess cash are more likely to make poor acquisitions. Agency theories predict an inverse relationship between cash-flows and abnormal returns.

Relative Size of Target on Acquirer

Asquith, Bruner and Mulherin [26] show that abnormal returns for acquirers increase in the ratio of the target’s equity capitalization to the acquirer’s equity capitalization. The inclusion of this variable allows to adjust for the impact of an acquisition on the equity market capitalization of the acquiring firm. Abnormal returns should increase with the relative size of target on acquirer if a dollar spent on acquisitions has the same return, regardless of the size of the acquisition.

Year

The inclusion of dummy variables for the year, controls for possible industry or economic shocks that happened in a particular year.

The sample includes only public firms, either acquirer or targets. Fuller, Netter and Stegemoller [36] show that abnormal returns are higher when targets are private firms or subsidiaries, rather than public firms. The final model selected includes only the variables that significantly explain abnormal returns in these samples.

5. Data

The sample of acquisitions is obtained from the Mergers and Acquisitions database in Securities Data Company (SDC). We select all transactions with announcement dates between 1999 and 2004 and require both the acquirer and the target to have a primary SIC code classified as either software, hardware, communications or services in Information
Technology, and at least one of the sides to have one industry segment with SIC classification as software. Other requirements for selection are that (1) the transaction is complete, (2) the transaction is not a stock repurchase, (3) both the acquirer and the target are public firms, (4) both the acquirer and the target are listed on CRSP and on Compustat (on both consolidated and industry-segment basis) databases during the event windows and (5) there are at least 75 trading days during the estimation period window. These requirements yield a sample of 193 M&As.

The information necessary to classify firms according to the layers of the stack comes from two sources. From the Compustat Industry Segment database we obtain the primary four-digit SIC codes for each segment reported by the company in the year previous to the announcement date of the transaction.

For a small sub-sample, we obtain data from the International Data Corporation (IDC) that provides enough information to classify sales on the five-layer stack. The IDC market classification allows the classification of sales as systems software, middleware software, applications software and services. The sub-sample with data from IDC comprises 45 M&As.

The market value of equity is obtained from CRSP and is equal to the number of shares outstanding times the price two days prior to the announcement of the transaction. From Compustat we also retrieve values for book assets, market equity, book equity, sales, earning before interest, taxes and depreciation, long-term debt, debt in current liabilities and preferred stock – redemption value. The classification of firms according to SIC codes was also imported from Compustat.

MVE (market value of equity) was obtained from CRSP and is equal to the number of shares outstanding times the price two days prior to the transaction. Market Value is defined as the
sum of market value of equity, long-term debt, debt in current liabilities, and the liquidating value of preferred stock. Tobin’s q is defined as the ratio of the value of book assets plus market equity minus book equity to the value of book assets. Leverage is calculated as the ratio of the firm’s debt (long-term+short-term+preferred stock) to the firm’s book value of common equity. The classification of sales as Hardware, Software and Services is based on the Compustat Industry Segment database.

6. **Empirical results and discussion**

The values of abnormal returns obtained for M&As are consistent with previous research. The results for the calculations of abnormal returns in the M&As sample are presented in Table 1. Our computations show significant average cumulative announcement abnormal returns for acquirers of -2.74% and for targets of 28.89%. In most previous papers, abnormal returns for acquirers are zero or negative and abnormal returns for targets are large. Evidence suggests that gains on mergers are limited to target shareholders. These results are in accordance with the results obtained in recent papers [37-40].

Using the three-layer stack, defined by the layers hardware, software and services, we find that mergers in which acquirers and targets have primary SIC codes in the same layer of the stack earn smaller abnormal returns than acquisitions in which acquirers and targets have primary SIC in different layers of the stack. This conclusion is true for abnormal returns for both acquirers, targets and combined. However, the difference tests based on t-tests for equality of means are significant at the 10% level only for acquirers and combined firms and insignificant for targets. We repeated the same analysis comparing instead abnormal returns from acquisitions in which acquirers and targets have the largest proportions of sales in the
same layer. We conclude that abnormal returns for acquirers are significantly higher, at 10% level, when acquirers and targets produce mostly in different layers. However, although we can also find higher abnormal returns for targets and combined abnormal returns when both sides have highest percentage of sales in different layers, difference tests based on t-tests for equality of means are still insignificant. Therefore, it seems that the results obtained using the three-layer stack do not fully explain abnormal returns obtained in M&As in software.

To determine the relation between concentration on a layer of the stack and abnormal returns after controlling for other variables that might affect abnormal returns obtained by acquirers and targets, we ran cross-sectional regressions of individual cumulative abnormal returns on a measure of concentration on layers of the stack.

From the Industry Segment database in Compustat, we classify a firm’s activity on a three-layer stack, as hardware, software or services. In this case, we use the concentration measure instead of the STACKD index, since the maximum distance between software and other activities can only be one layer apart and most of the activity in the sample is in software.

<table>
<thead>
<tr>
<th></th>
<th>ACAR Acquirer</th>
<th>ACAR Target</th>
<th>ACAR Combined</th>
<th>No. Obs.</th>
</tr>
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<tr>
<td>All transactions</td>
<td>-2.74%***</td>
<td>28.89%***</td>
<td>0.54%</td>
<td>193</td>
</tr>
<tr>
<td></td>
<td>(-5.064)</td>
<td>(39.951)</td>
<td>(0.870)</td>
<td></td>
</tr>
<tr>
<td>Cash transactions</td>
<td>0.79%</td>
<td>42.86%***</td>
<td>3.38%***</td>
<td>72</td>
</tr>
</tbody>
</table>

Table 1 - Announcement average cumulative abnormal returns for acquirers, targets and combined, sorted by concentration or distribution in the layers of the stack and form of payment.
Abnormal returns are calculated for a three-day window centered on the announcement date of the merger and calculated from a market model estimated from 231 to 31 days before the announcement date. The group Cash transactions includes transactions paid with at least 90% cash. The group Stock, mixed and other considerations is defined as transactions paid with stock, with a mix of cash and stock in which cash represents less than 90% of the payment, and other forms of payment. Primary SIC codes are classified according to the three-layer stack: hardware, software or services. t-statistics for abnormal returns are shown below each parameter estimate in parentheses.


<table>
<thead>
<tr>
<th>Stock, mixed and other considerations</th>
<th>-4.84%***</th>
<th>20.57%***</th>
<th>-1.15%**</th>
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<tr>
<td>z-score</td>
<td>(-6.892)</td>
<td>(21.753)</td>
<td>(-2.000)</td>
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<table>
<thead>
<tr>
<th>Acquirer/Target primary SIC in same layer (1)</th>
<th>-4.11%***</th>
<th>28.18%***</th>
<th>-0.84%</th>
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<tr>
<td>z-score</td>
<td>(-4.447)</td>
<td>(27.563)</td>
<td>(-0.063)</td>
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<table>
<thead>
<tr>
<th>Acquirer/Target primary SIC in different layers (2)</th>
<th>-1.38%***</th>
<th>29.59%***</th>
<th>1.89%</th>
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<tr>
<td>z-score</td>
<td>(-2.719)</td>
<td>(28.933)</td>
<td>(1.290)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Difference tests (1) –(2)</th>
<th>-2.12%*</th>
<th>-2.19%</th>
<th>-2.25%*</th>
</tr>
</thead>
<tbody>
<tr>
<td>z-score</td>
<td>(-1.739)</td>
<td>(-0.259)</td>
<td>(-1.701)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Maximum proportion of sales same layer (3)</th>
<th>-4.01%***</th>
<th>28.27%***</th>
<th>-0.29%</th>
</tr>
</thead>
<tbody>
<tr>
<td>z-score</td>
<td>(-5.042)</td>
<td>(29.149)</td>
<td>(0.271)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Maximum proportion of sales different layers (4)</th>
<th>-0.98%*</th>
<th>29.74%***</th>
<th>1.67%</th>
</tr>
</thead>
<tbody>
<tr>
<td>z-score</td>
<td>(-1.889)</td>
<td>(27.392)</td>
<td>(1.024)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Difference tests (3) –(4)</th>
<th>-3.03%*</th>
<th>-1.47%</th>
<th>-1.96%</th>
</tr>
</thead>
<tbody>
<tr>
<td>z-score</td>
<td>(-1.942)</td>
<td>(-0.2835)</td>
<td>(-1.223)</td>
</tr>
</tbody>
</table>

*** Statistically significant at the 1% level.
** Statistically significant at the 5% level.
* Statistically significant at the 10% level.

Table 2 reports the behavior of abnormal returns for acquirers and targets, and combined abnormal returns, as a function of concentration on the three-layer stack. In each case, the base model without the stack variable (1) and the complete model with the concentration variable (2) are presented. Acquirers’ abnormal returns and combined abnormal returns are significantly higher at a 10% level when investments are made in a different layer of the stack. However, there is no significant relation between targets abnormal returns and the measure of concentration on the stack.

The low level of significance obtained for the results suggests that the concentration or diversification on the three-layer stack explains little of the variation of abnormal returns in M&As in the software industry. To test if the software stack does indeed characterize the
industrial organization of the software industry, and can be the structure of a measure of complementarity between different software companies, we repeat the analysis using the five-layer stack.

We use the data from IDC to extend the analysis to the five-layer stack. Based on information obtained from the IDC on market classification, software sales are classified as systems software, middleware software or applications software. IDC also provides information for sales on services. From the Industry Segments database in Compustat, we obtain sales for hardware from Compustat. For each transaction the STACKD index is calculated.

The results are presented in Table 3. We start by studying the behavior of abnormal returns, if there is concentration on the same layer of the stack. This is a similar measure as in the previous analysis but using more detailed classification of layers. What was previously coarsely classified as software is here finely classified as systems software, middleware software or applications software. Model 2 shows that abnormal returns are decreasing with concentration in the same layer of the stack. This result brings some robustness to the conclusion that investment in complementary layers of the stack creates value in M&As. In Model 3, we add an extra variable to the model presented as Model 2. Besides concentration on the same layer of the stack we add one version of the STACKD index that includes investments in layers that are one, two, three or four levels apart. The component of the index for the distance between layers, $d_{ij}$, is defined as 0 if acquirers and targets are in the same layer, and 1, 2, 3 or 4, if they are one, two, three or four layers apart. The choice of these coefficients accounts for the fact that a variable for concentration in the same layer of the stack is considered separately. The results are still consistent with the previous conclusion:
concentration in the same layer of the stack is penalized in Mergers and Acquisitions. In addition, abnormal returns are significantly decreasing with the STACKD index. This means that as the index increases, that is, as the distance between acquirers and targets on the stack increases, returns decrease. It seems that acquisitions that focus on adjacent or closer layers of the stack have more value than acquisitions on same layer or layers further apart.

However, there is multicollinearity in Model 3, originated from very high correlations between the concentration measure and the STACKD index. It is easy to understand why both variables are highly correlated. When the proportion of sales of the combined acquirer/target on the same layer of the stack is higher, the proportion of sales on different layers has to be smaller. By definition, the sum of the weights on the STACKD index is equal to 1. For the same reason, the sum of the concentration variable and weights on the STACKD index is equal to 1. This means that the concentration variable is perfectly correlated with the weights of the index (and an index in which the coefficients are the same for all the distances). To alleviate this problem we include the concentration measure in the STACKD index, by defining a coefficient for sales in the same layer that is different from zero. We define $d_{ij}$ as 1, 2, 3, 4 and 5, if acquirer and target focus on the same layer, one layer apart, two layers apart, three layers apart or four layers apart.

Model 4 shows that, when this definition of the index is considered, the STACKD index is not significant in explaining abnormal returns. However, when we introduce the squared STACKD index variable in Model 5, both the STACKD index and the squared STACKD index are significant in explaining abnormal returns. Furthermore, the coefficient on the squared STACKD index variable is negative. This result points to a negative curvilinear relation between the STACKD index and abnormal returns. Abnormal returns are smaller for small
values of the STACKD index, increase as the index increases, and then decrease again as the index reaches higher values. These conclusion are consistent with the results from Model 3.

The results show that abnormal returns are higher when acquirers and targets produce products in adjacent layers of the software stack, and are smaller when they produce in the same layer or in layers that are further apart. We interpret this as evidence for complementarity as a source of value creation in Mergers and Acquisitions.

Table 2 - Cross-sectional regression analysis of acquirer’s, targets and combined announcement abnormal returns in Mergers an Acquisitions using entire sample

Abnormal returns are calculated for a three-day window centered on the announcement date of the merger from a market model estimated from 231 to 31 days before the announcement date. The following control variables were introduced in the model (and some later dropped): Method of Payment, Transaction Value, Percentage of Target Acquired, Acquirer’s Equity Value, Acquirer’s Market Value, Acquirer’s Tobin q, Acquirer’s Leverage, Acquirer’s cash-flow, Relative Size Target/Acquirer, Year and Concentration in Layers of the Stack. Payment with Cash is a dummy variable equal to one if the method of payment is at least 90% cash. Relative size Target/Acquirer is the ratio of the equity values of target and acquirer. Concentration in Layers of the Stack is the sum of the product of proportions of sales for acquirer and target in the same layer of the three-layer stack. t-statistics are reported below each coefficient in parentheses.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Combined (1)</th>
<th>Combined (2)</th>
<th>Acquirer (1)</th>
<th>Acquirer (2)</th>
<th>Target (1)</th>
<th>Target (2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>0.0953*</td>
<td>0.1273**</td>
<td>0.0302</td>
<td>0.0574</td>
<td>0.0276</td>
<td>0.0352</td>
</tr>
<tr>
<td></td>
<td>(1.894)</td>
<td>(2.3965)</td>
<td>(0.6667)</td>
<td>(1.1992)</td>
<td>(0.3016)</td>
<td>(0.3812)</td>
</tr>
<tr>
<td>Concentration in Layers of Stack</td>
<td>-0.0292*</td>
<td>-0.0279*</td>
<td>-0.0417</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(-1.7956)</td>
<td>(-1.7068)</td>
<td>(-0.7347)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Payment with Cash</td>
<td>0.0622***</td>
<td>0.0609***</td>
<td>0.0643***</td>
<td>0.063***</td>
<td>0.2618***</td>
<td>0.2599***</td>
</tr>
<tr>
<td></td>
<td>(3.824)</td>
<td>(3.7574)</td>
<td>(3.9294)</td>
<td>(3.8654)</td>
<td>(4.803)</td>
<td>(4.757)</td>
</tr>
<tr>
<td>Acquirer Equity Value</td>
<td>-0.0083**</td>
<td>-0.0093***</td>
<td>-0.0055*</td>
<td>-0.0064**</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(-2.4805)</td>
<td>(-2.7722)</td>
<td>(-1.7744)</td>
<td>(-2.0265)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Relative Size Target/Acquirer</td>
<td>0.0378***</td>
<td>0.0355**</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(2.586)</td>
<td>(2.436)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Percentage of Target Acquired</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.0018**</td>
<td>0.002**</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(2.586)</td>
<td>(2.436)</td>
</tr>
</tbody>
</table>
Furthermore, this result is statistically significant at the 5% level and we can conclude that a more detailed definition of the software stack explains more of the variation of abnormal returns in M&As between software companies than the three-layer stack considered previously.

In model 6, we break the different components of the STACKD index and construct separated variables for concentration and investment in one, two, three or four layers apart. The obtained results are accordance with the major results obtained before. The coefficient for same layer is negative, indicating an inverse relation between abnormal returns and concentration. The coefficient for One layer distance is positive, providing evidence of gains in acquisitions in adjacent layers. Both the coefficient for Two layers apart and the coefficient for Four layers apart are negative and the second is smaller than the former, demonstrating that as the distance between acquirers and targets on the stack increases abnormal returns decrease. However, for the same reasons explained for Model 3, also Model 7 exhibits multicolinearity. We test for the equality of the coefficients and obtain significance for the difference between the coefficients of Same Layer and One Layer distance, and the coefficients of One Layer distance and Three Layers distance.
Abnormal returns are calculated for a three-day window centered on the announcement date of the merger from a market model estimated from 231 to 31 days before the announcement date. The following control variables were introduced in the model (and some later dropped): Method of Payment, Transaction Value, Percentage of Target Acquired, Acquirer’s Equity Value, Acquirer’s Market Value, Acquirer’s Tobin q, Acquirer’s Leverage, Relative Size Target/Acquirer and the STACKD Index. Payment with Cash is a dummy variable equal to one if the method of payment is at least 90% cash. Relative size Target/Acquirer is the ratio of the equity values of target and acquirer. The STACKD Index is the sum of the product of proportion of sales for acquirer and target in each of the layers of the five-layer stack, either in the same layer or in different layers, multiplied by a coefficient that defines the distance on the stack for each pair of considered layers. In Model 3, the coefficients for STACKD1 are: 0 for the same layer, 1 for one layer distance, 2 for two layers distance, 3 for three layers distance and 4 for four layers distance. In Model 4 and Model 5 the coefficients for STACKD2 are: 1 for the same layer, 2 for one layer distance, 3 for two layers distance, 4 for three layers distance and 5 for four layers distance. In Model 6, Same layer, One layer, Two layers, Three layers and Four layers is equal to the product of proportion of sales of the acquirer in one layer times the proportion of sales of the target in the same layer, or one layer, two, three or four layers apart. t-statistics are reported below each coefficient in parentheses.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Model 1</th>
<th>Model 2</th>
<th>Model 3</th>
<th>Model 4</th>
<th>Model 5</th>
<th>Model 6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>-0.0046</td>
<td>0.0092</td>
<td>0.1091***</td>
<td>0.0056</td>
<td>-0.0935*</td>
<td>0.0468</td>
</tr>
<tr>
<td></td>
<td>(-0.3793)</td>
<td>(0.6545)</td>
<td>(3.4137)</td>
<td>(0.1997)</td>
<td>(-1.8479)</td>
<td>(0.00442)</td>
</tr>
<tr>
<td>Size Target/Acquirer</td>
<td>0.1069**</td>
<td>0.1168***</td>
<td>0.0896**</td>
<td>0.1027**</td>
<td>0.1067*</td>
<td>0.0901**</td>
</tr>
<tr>
<td></td>
<td>(2.5736)</td>
<td>(2.8548)</td>
<td>(2.3947)</td>
<td>(2.3797)</td>
<td>(2.5923)</td>
<td>(2.2943)</td>
</tr>
<tr>
<td>STACKD1</td>
<td></td>
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<tr>
<td></td>
<td>-0.0531***</td>
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<tr>
<td>STACKD2</td>
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<tr>
<td></td>
<td>-0.0044</td>
<td>0.0919**</td>
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<td></td>
<td>(-0.4039)</td>
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<td>STACKD2^2</td>
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<tr>
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<td>-0.0195**</td>
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<td></td>
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</tr>
<tr>
<td></td>
<td>(-2.3019)</td>
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</tr>
<tr>
<td>Same layer / Concentration</td>
<td>-0.0429*</td>
<td>-0.1396***</td>
<td></td>
<td></td>
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<td>-0.0779</td>
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<tr>
<td></td>
<td>(-1.7804)</td>
<td>(-3.9127)</td>
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<td>(-0.0738)</td>
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<tr>
<td>One layer distance</td>
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<td>0.0134</td>
</tr>
<tr>
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<td></td>
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<td></td>
<td>(0.0127)</td>
</tr>
<tr>
<td>Two layers distance</td>
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<td>(-0.0284)</td>
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</table>
Table 6 (continued)

<table>
<thead>
<tr>
<th>Distance</th>
<th>Coefficient</th>
<th>t-statistic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Three layers distance</td>
<td>-0.1232</td>
<td>(-0.1158)</td>
</tr>
<tr>
<td>Four layers distance</td>
<td>-0.0875</td>
<td>(-0.0825)</td>
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</table>

<table>
<thead>
<tr>
<th></th>
<th>R^2</th>
<th>F-statistic</th>
<th>N</th>
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<tbody>
<tr>
<td></td>
<td>0.1335</td>
<td>6.623</td>
<td>45</td>
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<td>0.1943</td>
<td>5.064</td>
<td>45</td>
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<td></td>
<td>0.3715</td>
<td>8.078</td>
<td>45</td>
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<td>4.213</td>
<td>45</td>
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<tr>
<td></td>
<td>0.3994</td>
<td>4.212</td>
<td>45</td>
</tr>
</tbody>
</table>

*** Statistically significant at the 1% level.
** Statistically significant at the 5% level.
* Statistically significant at the 10% level.

Testing the equality of the coefficients in Model 7 using a F-test.
“Same layer” and “One layer distance”: F-statistic=7.907761
“One layer distance” and “Two layers distance”: F-statistic=0.49826
“One layer distance” and “Three layers distance”: F-statistic= 3.7911
“One layer distance” and “Four layers distance”: F-statistic= 0.56414

We reject the null hypothesis that the coefficients for the variables “Same layer” and “One layer distance” and the coefficients for the variables “One layer distance” and “Three layers distance”. We cannot reject the null hypothesis that the coefficients for the variables “One layer distance” and “Two layers distance” and the coefficients for the variables “One layer distance” and “Four layers distance” are equal.

Overall, the results show some robustness in providing evidence of an inverse curvilinear relationship between abnormal returns and the STACKD index and validate the hypothesis that there is value in M&As between components of complementary networks.

The value of a merger between software companies depends on how easy it is to technical integrate the products of both companies. There is value creation only if potential synergies and complementarities are realized. Very often the outcome of mergers between similar software companies is not very successful because these companies have problems with the technical integration of the software products. In practice the integration may take time or not happen at all. When products are complements, in the sense that they can be coupled, integration may not always be easy, but when products are already working as complementary
components on the provision of a product, integration is not an uncertainty. In many cases, companies are already partners before they merge.

One of such examples is EMC, a company with core business traditionally in large data-storage computers that in recent years has been using acquisitions to move into data-storage software, products that help companies store information and manage it more easily and efficiently. EMC’s strategy can be justified by two major motivations: to complement the core business of the company, which is storage hardware, and to gain competitive advantage relatively to IBM, its major competitor. But while EMC’s strategy has been generally well received, mergers such as the one between Stellent and Optika, two firms positioned in the middleware layer of the software stack, did not get a very favorable market reaction. Both companies showed cumulative abnormal returns in the three days surrounding the announcement of the merger around –10%. The companies justified their integration as a strategy to expand their portfolio of products and services and to obtain economies of scope. However, the market viewed the transaction as a movement towards consolidation and there were doubts about overlapping and the technical integration of their products.

When the products are highly complementary, companies may want to integrate if customers value a more reliable systems integration supplied by a single provider. Tight integration may also allow companies to compete at the level of systems and establish winning standards.

Therefore, the choice of the organizational form in which companies should integrate depends on how to effectively realize the value of synergies and complementarities. When complementary products are already working together as components of a network system, through a common platform, the value of synergies is already realized and companies may want to internalize it. M&As, allowing firms to hold equity stakes in complementary
companies, may also lead to the realization of value from the internalization of complementary network externalities.

9. Conclusions

The results provide evidence that there is value in M&As between complementary components of network systems. We find that M&As between companies that are in adjacent layers earn higher abnormal returns than M&As between companies which are in the same layer or in layers further apart on the stack. By definition, layers of the software stack that are closer together exhibit stronger complementarities. We interpret these results as evidence that complementarity is a source of value creation in M&As. Technical integration between products of similar companies may be difficult, but when products are in different layers of the software stack they may already be working together as complementary components of a network system. Companies may want to internalize the value of complementary network externalities through M&As. This provides some evidence that there is value in equity participation between firms that are complementary components of a network system.
10. References


