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Ex ante identification of disruptive innovations in the software industry applied to web applications: The case of Microsoft's vs. Google's office applications

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ABSTRACT

This paper analyzes the question whether web applications pose a disruptive threat to incumbents or a disruptive growth opportunity for entrants in the application software industry using a novel method for ex ante identification of disruptive innovations in the software industry. Building on the theory of disruptive innovations, network effects and existing frameworks for the ex ante identification of disruptive innovations a new method of analysis is deduced. The analysis is based on a list of criteria that indicate a disruptive innovation and trajectory maps of the technologies' performance attributes. This method is applied to study the potential disruption of Microsoft's desktop office applications by Google's web-based office applications.

The chosen method of analysis indicates a small likelihood for web applications to pose a disruptive threat to Microsoft, and by extension, to incumbents in the software industry. While web applications show a potential to satisfy market demand in established performance attributes, strong network effects in existing software products should give incumbents enough time to co-opt the innovation. The case illustrates how our new method to analyze disruptive potential in the software industry ex ante can help to apply the theory of disruptive innovation better for forecasting purposes and to provide novel strategic insights for the players involved.

1. Introduction

The Web 2.0 buzz and the rise of a number of profitable Internet companies have led to a resurgence of Internet activity. One of the innovations powering the web, the web application, has received particular attention. Instead of being based on any specific operating systems, web applications run on a stack of Internet standards, server-based software and modern web browsers [1]. This platform provides an alternative to the old model, where software is dependent on the environment provided by the (mostly proprietary) operating system [2]. Already the press has picked up on the potential threat a platform shift could pose for incumbents in the software industry [3,4]. This situation lends itself well to an analysis with the disruptive innovation framework pioneered by Christensen [5].

According to Christensen, only disruptive innovations can pose a serious threat to incumbent firms. Therefore we apply Christensen's theory to perform an ex ante analysis of the disruptive potential of web applications in this paper. There still seems to

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be a lack of definite frameworks for the ex ante identification of disruptive innovations [6,7]. In this paper we base our new method on previous studies by Rafii and Kampas [8], Christensen et al. [9] and Hüsig et al. [6]. These approaches are further enhanced by the inclusion of network effects theory as it applies to software markets [10–12]. A new and improved method to analyze new technologies' disruptive potential ex ante based on the disruptive innovation and network theory is proposed. This method could be used to check the disruptive potential of further innovations for future firm and technology strategies. Our case could also be seen as an example of how to apply our new method to a real-world phenomenon.

As the ex ante viewpoint is fraught with uncertainties [6], the primary objective is not to give an answer to the ultimate question "disruptive or not". Rather, we will provide insights into the underlying mechanics of the software industry as they relate to the web application innovation that will be valuable for entrants as well as incumbents when implementing web applications. The suggestions made in our paper could themselves alter the ultimate outcome of the ex ante analysis regarding the disruptive potential if implemented by the incumbents and entrants analyzed here. Since the future is unwritten yet, proactive players can utilize superior knowledge to their advantage and change the trends observed in the past. Therefore this paper could be seen as a contribution to the development of future strategies for the implementation of the technologies analyzed here.

The following chapters give a brief overview of the disruptive innovation theory and its utilization for forecasting purposes, leading to a new method for analyzing the disruptive potential of innovations in the software industry. After that the technology – in this case web applications – is described and the method is applied to Microsoft's vs. Google's office applications. The resulting analysis provides the disruptive potential of web applications in this context and is used to propose new strategic recommendations and implications for the incumbents as well as the entrants involved. Limitations and options for future research finalize our paper.

2. The theory of disruptive innovations and the concept of disruptive potential

Christensen introduced the concept of disruptive technologies [5], also referred to as disruptive innovations [13]. He described a disruptive innovation as a change in the process of creating a product/service. It shifts customer expectations and competition to new performance attributes and ultimately leads to the failure of incumbents. This is in contrast to a sustaining innovation, which improves performance along established attributes and is typically mastered by the incumbent. Christensen identified the processes and values of incumbents as the culprit. The disruptive innovation requires new processes and is incompatible with the incumbent's values. Incumbents therefore have difficulty implementing the innovation and/or ignore the innovation for too long, allowing the entrant to disrupt their market [5].

In order to clarify the mechanics of the disruptive innovation, we reviewed a number of critiques and enhancements of Christensen's theory. Adner [14] argues, that the shift of customer expectations to new performance attributes is not well explained. He introduces a demand-based view and suggests that an absolute lower unit price is crucial for the disruption to occur. This fits with Christensen and Raynor's [13] concept of low-end disruptions, which target existing customers with significantly lower prices. Govindarajan and Kopalle [15] identified high-end disruptive innovations that initially seem to contradict this view. A high-end disruption starts as more expensive than the existing solution and for this reason is ignored by incumbents, e.g. the iPod. In this view, price is simply one more performance attribute of the product/service. Govindarajan and Kopalle [15] then also follow a demand-based view and explain the shift in customer expectations with the disruptive innovation eventually offering *sufficient performance* in established attributes, while offering *additional performance attributes*. With marginal utility of performance in the established attributes declining once sufficiency is reached [14], the utility derived from the additional attributes may become decisive for customers' decisions. This extends, but does not contradict, Christensen's [5] supply-based explanation, where oversupply in existing attributes eventually shifts competition to new performance attributes.

One important issue for the ex ante identification of an innovation's disruptive potential is the failure of incumbents. Research shows that not all incumbents fail. For example, Japanese hard disk manufactures survived the same (disruptive) innovations that led to a failure of incumbents in the United States [16]. Regional differences could be decisive here. Gilbert [17] argues, that a successful management of disruptive innovations at the level of top management is possible. However, Christensen's claim that incumbents lose their dominant market position remains untested [7]. Charitou and Markides [18] introduce the concept of a disruptive strategic innovation, which is based on a new business model and potentially allows for a long-term co-existence of entrants and incumbents.

The different enhancements to Christensen's theory discussed here might overstretch the original concept [7]. However, when consolidated, they can lead to a clearer view of the mechanics of a disruptive innovation. By taking Christensen's original theory, its criticism and enhancements into account, we identified the following characteristics for a disruptive innovation:

(1) The innovation allows for a product with a new combination of performance attributes (including the price).
(2) The resulting product misses main market expectations in one or more established attributes and therefore targets only a niche.
(3) Incumbents ignore the niche because of incompatible processes or values.
(4) Entrants develop the innovation further and resulting products start to satisfy main market expectations in established performance attributes.
(5) Incumbents lack necessary competencies in the innovation. They cannot provide the new performance attributes and fail.

As discussed above, (5) is far from certain. This raises the question, if innovations can be called disruptive, when incumbents do not fail [7]. For the purpose of ex ante identification we therefore derived the following definition: we measure the ex ante disruptive potential of an innovation by the *threat* it poses to incumbents to ultimately fail.

3. Development of a new methodical framework to analyze disruptive potential

There still seems to be a lack of definite frameworks for the ex ante identification of disruptive innovations [6,7]. In this paper we base our method on previous studies by Rafii and Kampas [8], Christensen et al. [9] and Hüsig et al. [6]. These approaches are further enhanced by the inclusion of network effects theory as it applies to software markets [10–12]. To support the resulting criteria-based framework for the ex ante identification of disruptive innovation with more quantitative measures, we also construct trajectory maps [5–7].

3.1. Criteria sheet

To compile an effective criteria sheet for the ex ante identification of disruptive innovations, the research of Rafii and Kampas [8], Christensen et al. [9], and Hüsig et al. [6] was reviewed. All three approaches seek to identify the disruptive potential of an innovation by measuring it against criteria, which are based on Christensen's original theory. An overview and comparison of these three approaches is given in Table 1. We consolidated these existing approaches into a single criteria sheet to gain as broad a view of the innovation as possible.

Apart from the criteria themselves, useful additions to the methodology could be drawn from each approach. In order to consolidate the criteria on the sheet and derive a general tendency without being overly quantitative, Hüsig et al. [6] suggest a three-staged rating (fulfilled/not-fulfilled/unknown) for each criterion. Christensen et al. [9] highlight the importance of considering the implementation of an innovation within a firm's products and frequently distinguish between entrant and incumbent. We therefore distinguished the criteria by their description of either the entrant's or the incumbent's situation. Such a distinction should provide further insights into the causal relationships of the disruption. Rafii and Kampas [8] suggest a division of the criteria into multiple phases, giving credit to the dynamic character of the disruption. “Since disruption is generally a serial process, a very strong disabling factor can prohibit it early on” [8, p122]. For our purposes, a distinction of three phases seemed most appropriate:

(1) Foothold market entry: the innovation grows successfully in a market niche.
(2) Main market entry: the innovation enters the mainstream market.
(3) Failure of incumbents: incumbents fail, because they cannot successfully implement the innovation themselves.

One aspect neglected by all three approaches is the potential influence of network effects. Network effects occur, when the value of a good increases with the number of users of that good [11]. A classic example is the fax machine [11]. For the analysis of a software innovation, this appeared to be critical, as software products commonly give rise to a number of network effects [11,19]. Therefore, innovation in software markets is influenced by network effects [11,12]. Historically, disruptions have occurred less frequently in software markets [20]. However, there is no evidence that network effects make innovations impossible [21]. It appeared therefore useful to include indicators about the extent network effects work in favor or against the potential disruption. One indicator is the extent to which switching costs occur. These are common in software in the form of data, training or infrastructure [11,12]. Further, coordination costs arise between multiple, interacting users of a software product, which favors the old technology [19]. Another indicator is customers' expectations of the future network size of a product, which have been shown to influence buying decisions [10,22,23]. A key success factor for an innovation is also its compatibility with the old network, as compatibility allows the entrant to appropriate existing network effects [11]. We therefore added switching costs, coordination costs, customer expectations and compatibility as criteria in the *Main market entry* phase of our criteria sheet. These network effects-related criteria enhance the consolidated criteria sheet we could derive from the existing approaches for evaluating disruptive potential.

All criteria were noted in their disruption-positive form. That is, if the criterion is fulfilled, a disruption is more likely to occur. The resulting criteria sheet for ranking a potentially disruptive innovation (PDI) can be found in Table 2.

Table 1
Comparison of existing methods for the ex ante identification of disruptive innovations.

	Rafii/Kampas	Christensen/Anthony/Roth	Hüsig/Hipp/Dowling
Focus of method	Disruptive threats for incumbent	Industry change due to innovations	Disruptive potential of a technology
Scale or classification	Seven-point scale: −3 (=not disruptive) to +3 (=disruptive)	Qualitative assessment	Yes (=disruptive), No (=not disruptive),Unknown
Grouping of criteria	Six stages of the disruption process	Three stages	–
Accounting of network effects	Only switching costs	–	Outside of main questionnaire

Table 2
Criteria to measure the disruptive potential of an innovation in software markets.

Phase	Entrant	Incumbent
Foothold market entry	• Products perform worse based on established attributes • Products are cheaper, simpler, more comfortable or more reliable • Products address current non-consumers • Profitable business model targeting over-satisfied customers • Investors allow experimentation	• Some customers are over-satisfied • Main customer segment does not appreciate entrant's products • Market for products based on PDI appears small and irrelevant
Main market entry	• Products are based on standard components • Strategic resources (licenses, capital, etc.) are accessible • Network for PDI is expected to be large • PDI is compatible with existing network	• Established performance attributes are shifting • Customers are unwilling to pay for further improvements along established attributes • Switching costs are low • Coordination costs are low
Failure of incumbent	• Business model is significantly different • Processes are significantly different • Value network has a low overlap	• Products matching entrant's offer are not added • Incumbent is fleeing to premium customer segments • PDI is not implemented in separate organization

3.2. Trajectory maps

Trajectory maps are considered very useful for the ex ante analysis of a potentially disruptive innovation [6,7]. A trajectory map tracks the performance of the existing technology, the new technology and market demand along *established performance attributes* (Fig. 1). A disruption can only occur, if the new technology is capable of meeting performance demanded in the mainstream market [5]. Price trajectories are an enhancement of this concept. They are based on Adner's [14] demand-based view of disruptions. From Adner's work we derived the idealized price trajectories in Fig. 1: The disruptive potential is increased, if the disruptive technology offers a smaller unit price [14].

Similarly to the criteria sheet developed above, we formalized the idealized trajectory of a disruptive innovation in the following criteria:

- The performance trajectory of the PDI intersects the (lower) demand trajectory [6].
- The performance trajectory of the established technology overshoots the (lower) demand trajectory [6].
- The performance trajectory of the PDI shows a steep curve (fast attack on incumbent) [8].
- The price trajectory of the PDI intersects the price trajectory of the established technology from above or stays always below [14].

4. Application of the methodology to web applications and the case of Microsoft's vs. Google's office applications

In this section we apply the developed method to determine the disruptive threat that web applications pose for software incumbents. After an overview of the technology in question, we focus on the case of Microsoft's vs. Google's office applications.

4.1. The technology in question: Web applications

A web application is a program running on a central server on the Internet and accessed via a web browser [1]. A further development is AJAX (Asynchronous JavaScript and XML), a framework of standardized Internet technologies that allows for

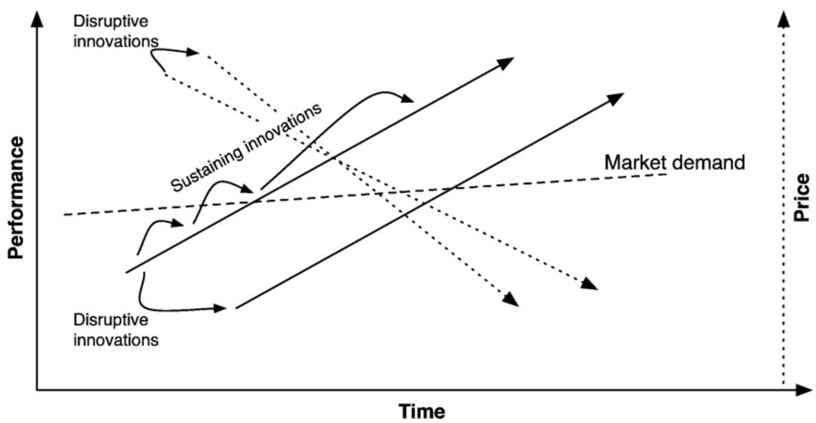

Fig. 1. Disruptive innovations create a new performance and price trajectory. Sustaining innovations, in contrast, move a product or service along its existing trajectory [5,14].

Table 3
Properties of web- and desktop applications [1,2].

Web applications	Desktop applications
• Platform/OS independent. • Require a web browser. • Based on Internet standards. • Operate above the level of a single device. • Managed centrally. • Quickly and continuously incorporate user feedback.	• Tied to an operating system's application program interface (usually Microsoft Windows). • Offer a high degree of interactivity. • Allow for a rich user experience.

asynchronous communication between the web browser and the application server and increase web application interactivity [2,24,25]. Table 3 lists the properties of web- and desktop applications.

The properties of web applications resemble the concept of a "computer utility" from 1964 [26]. The idea then was, that computing power could be provided to the public like other utilities such as electricity or gas. In the 1970s this concept failed due to complexity of the required server software [26]. With web applications, this concept is revived, but this time it is built on the robust Internet infrastructure.

Web applications break a trade-off that existed between rich and thin clients. While a thin client allows for central management, it offers poor interactivity and user experience. A rich client in turn, requires locally managed and installed software. Modern web applications offer a high degree of interactivity, require only a web browser on the local machine, and can be managed centrally [1,2]. This trade-off is visualized in Fig. 2.

Web applications are often accompanied by a new business model, referred to as Software as a Service (SaaS), where software is financed by subscriptions, transaction fees or advertisements instead of retail sales or volume license deals [2,27]. Table 4 provides a few examples for incumbent and entrant products that indicate some disruptive potential in the area of desktop vs. web applications.

4.2. The case: Microsoft vs. Google's office applications

It was not feasible to make a complete survey of the disruptive potential for the entire software industry because of the many existing web application and desktop application software products. Therefore our analysis focused on the example of Microsoft and Google. Microsoft owns the de-facto desktop software platform (through Windows) and produces a range of successful desktop software products. Google is a pioneer of modern web applications and uses the Internet as a platform for most of its products. Also, the press usually focuses on these two companies as examples for a coming paradigm shift [3,4]. Microsoft and Google are therefore representative for incumbents and entrants dealing with the web application innovation. Data for both companies was sampled from a wide range of industry magazines, newspaper articles, weblogs and the companies' annual reports. With the disruptive criteria sheet (cf. Table 2) in mind, we compiled the following company profiles and marked our results in the criteria sheet separately for the entrant and incumbent (cf. Tables 5 and 6). A combined overview of the results is provided in Fig. 3.

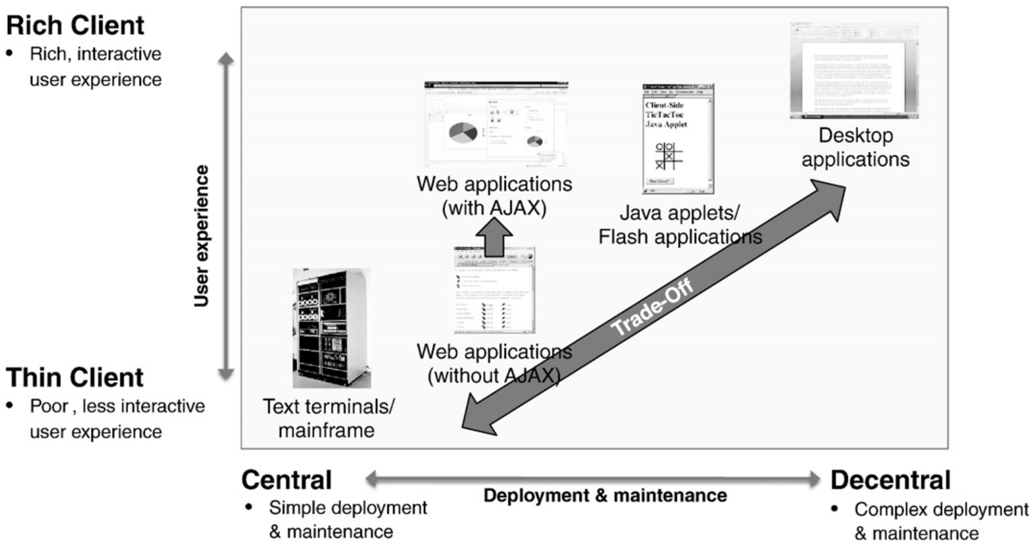

Fig. 2. Web applications break trade-off between rich and thin clients.

Table 4
Examples of incumbent and entrant software products grouped by the job they fulfill.

Job	Product implemented as desktop application (incumbent)	Product implemented as web application (entrant)
Word processing	Microsoft Word	Google Docs Yahoo! Zimbra
Spreadsheet	Microsoft Excel	Google Docs Yahoo! Zimbra
Email Management	Microsoft Outlook	Google Mail Yahoo! Mail Yahoo! Zimbra
Photo Management	Adobe Photoshop Elements	Yahoo! Flickr
CRM Software	SAP CRM	Salesforce.com CRM

4.3. Results for Microsoft: Moving towards software as a service?

Microsoft's main customer segment is with enterprise customers and original equipment manufacturers (OEMs), which account for three-fourths of its revenue [28]. Its business model is built around developing operating systems and desktop software packages that are licensed to OEMs and enterprises [28]. Microsoft's processes are optimized for this model. Major new software releases are developed in a complex, multi-year development process involving a large number of software engineers [29]. Similarly, sales processes mainly target large enterprises, governments and OEMs [30].

These clients do not find web applications attractive, because of security concerns and a high demand for performance and features [31,32]. Microsoft's software is sometimes criticized for providing unused features and has been found to overshoot user requirements [33]. However, its main customers show a continued willingness to pay for software upgrades along established performance attributes, as is reflected in rising sales for the most recent version of its office product line, “Office 2007” [34]. At the same time though, Microsoft is not fleeing into higher customer segments. For example, it keeps offering low-priced versions of its software for students and consumers [35].

Besides the usual switching costs associated with software products, the company also profits from coordination costs. A large network of users exchanging files in Microsoft's proprietary formats makes a product change for any individual user less likely [11,12,32]. Although this gives Microsoft a strong market position, it is taking the threat posed by web applications seriously.

Recently, Microsoft has been moving towards the Software as a Service model, offering a mix of web and desktop applications to consumer and business clients [30,36]. Since 2007 Microsoft's consumer web application efforts are concentrated under the “Windows Live” brand and organized in the “Online Services Business” unit [28,37,38]. A web version of its office products, branded “Office Live”, is developed in the “Microsoft Business Division” — the same organization responsible for the desktop version of its application suite [4,28,31]. It has also taken steps to copy Google's entire product line, including online search and advertisements [28,37,38], indicated also by its attempt to take over Yahoo [39]. This profile is reflected in the criteria sheet in Table 5.

4.4. Results for Google: From search to office applications

Google offers Internet search services and has built a profitable business model around context-sensitive advertisements [40]. Key processes involve the management of complex server software that answers incoming requests, updates databases and searches large data repositories [2,41]. Google's software development processes are optimized for frequently updating its web applications based on user feedback [2]. The company is trying to keep a culture of experimentation alive, for example by encouraging its employees to devote 20% of their time to projects of their own initiative [42].

Table 5
Disruptive criteria sheet for Microsoft's office applications (incumbent).

Phase	Criterion	Fulfilled	Not fulfilled	Unknown
Foothold market entry	Some customers are over-satisfied	X	–	–
	Main customer segment does not appreciate entrants products	X	–	–
	Market for products based on PDI appears small and irrelevant	–	X	–
	Phase total	2	1	0
Main market entry	Established performance attributes are shifting	–	–	X
	Customers are unwilling to pay for further improvements along established attributes	–	X	–
	Switching costs are low	–	X	–
	Coordination costs are low	–	X	–
	Phase total	0	3	1
Failure of incumbent	Products matching entrant's offer are not added	–	X	–
	Incumbent is fleeing to premium customer segments	–	X	–
	PDI is not implemented in separate organization	X	–	–
	Phase total	1	2	0
	Total	3	6	1

Table 6
Disruptive criteria sheet for Google's office applications (entrant).

Phase	Criterion	Fulfilled	Not fulfilled	Unknown
Foothold market entry	Products perform worse based on established attributes	X	–	–
	Products are cheaper, simpler, more comfortable or more reliable	X	–	–
	Products address current non-consumers	–	X	–
	Profitable business model targeting over-satisfied customers	X	–	–
	Investors allow experimentation	X	–	–
	Phase total	4	1	0
Main market entry	Products are based on standard components	X	–	–
	Strategic resources (licenses, capital, etc.) are accessible	X	–	–
	Network for PDI is expected to be large	–	X	–
	PDI is compatible with existing network	–	X	–
	Phase total	2	2	0
Failure of incumbent	Business model is significantly different	X	–	–
	Processes are significantly different	X	–	–
	Value network has a low overlap	X	–	–
	Phase total	3	0	0
	Total	9	3	0

Google uses web applications technology in almost all of its services [2,4,43]. Web applications are suitable for the rapid application development employed by Google [1]. Its suite of office applications, Google Docs, is explicitly targeting Microsoft's overshot customers [40,44]. Google Docs offers less features and speed than Microsoft's desktop applications [43,45]. The software does not require installation and is available for free online to anyone with a web browser [43–45]. When looking at the price only, Google's offer can also be seen as competing with open source software packages like OpenOffice, which have aimed to offer a free alternative to Microsoft Office products [43]. In this regard, the potential to reach non-consumers appears limited.

Google has access to key resources for software development, such as highly qualified employees and capital [26,30,41,46]. The company circumvents any potentially restricted access to distribution channels by using the Internet exclusively as its software distribution platform, where it has established a strong brand [41]. A key restriction for Google Docs' competitiveness in the market place though, is a lack of full compatibility with Microsoft's proprietary file formats [32,43,45]. Historically, competitors have failed to attain compatibility with Microsoft's complex products [12]. This profile is reflected in the criteria sheet in Table 6.

4.5. Trajectory maps for storage capacity and software features

Danneels [7] notes the difficulty of using one axis for a combination of all performance attributes. The multitude of potential attributes and correlations between them could render a real-world study impossible [7]. We therefore chose to study the performance of two suitable attributes, *storage capacity* and *software features*, in separate trajectory maps. *Storage capacity* was chosen, because one of the key features of software is its ability to manage and store the users' documents. This is especially relevant for email software, where a user might have thousands of individual documents. While desktop applications can rely on local storage provided by the user, web applications need to provide their storage online. *Software features* was chosen because the more possible user interactions (i. e. features) a software product offers, the higher its degree of flexibility and adequacy for various and/or complex tasks.

For *storage capacity*, we analyzed the email storage space available for webmail and classic desktop email software (cf. Fig. 4). Desktop email software saves information on local hard drives, so available desktop hard drive capacity served as a proxy for this

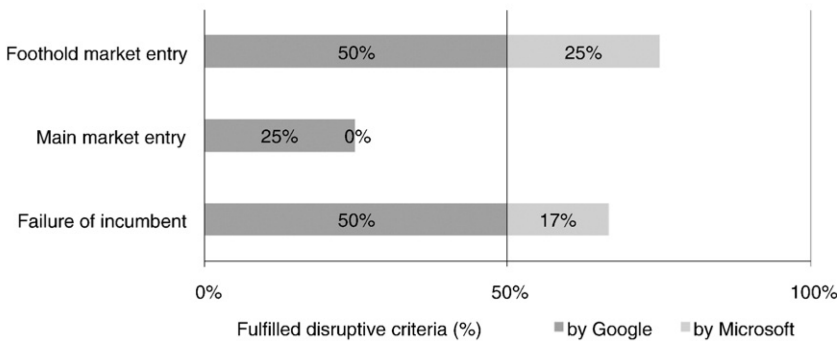

Fig. 3. Fulfilled disruptive criteria for the case of Google's web-based office applications.

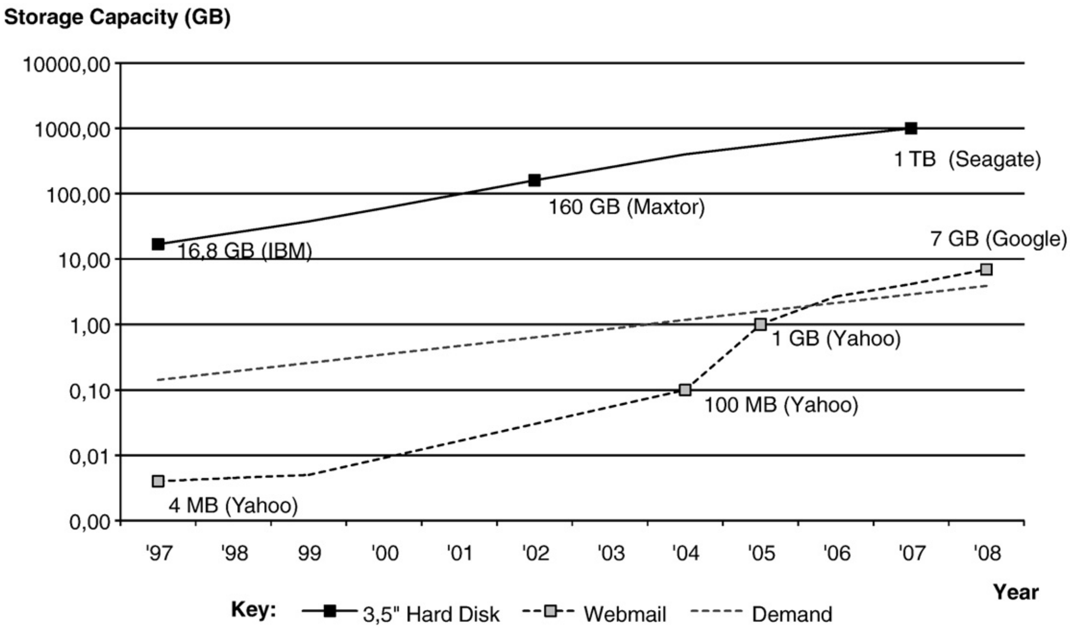

Fig. 4. Storage capacity of desktop disk drives vs. webmail storage.

measure. Data points were then gathered from hard disk manufacturers and webmail providers' press releases. Demand for email storage was measured based on a study by Craine [47], which found a 35% year-to-year growth in demand.

In the resulting trajectory map (cf. Fig. 4), webmail services fulfill all our criteria for a disruptive technology:

- The performance trajectory of webmail intersects the demand trajectory: webmail is capable of offering suitable storage capacity for customers.
- The performance trajectory of hard disk drives overshoots the demand trajectory: in fact, desktop hard disk drives have historically offered much more storage space than is required for the comparably small email messages.
- The performance trajectory of the PDI shows a steep curve (fast attack on incumbent): the improvements in webmail storage space from “significantly below demand” to “above demand” happened within a relatively short timeframe of two years (2005/06), compared to eight years of below-demand performance.
- The price trajectory of the PDI intersects the price trajectory of the established technology from above or stays always below: as all webmail services included in the data were offered free of charge, the price trajectory criterion was trivially fulfilled.

For the *software features* attribute we focused on the number of features available in the word processing software Microsoft Word and Google Docs. For Microsoft Word, press releases and studies provided historical data points [33,48,49]. For Google Docs, we counted the number of features manually based on the German version available for free online at http://docs.google.com on February 25, 2008. To determine the number of features we used the following heuristic [33]:

- A final, graphic user interface element counts 1. An element is not final, if it opens a sub-menu.
- A choice between equivalent options like color, font or size counts 1.
- Identical operations found in two different menus are counted only once.

Google Docs offered a total of 141 operations (cf. Table 7). Historical data for Google Docs was not available. From the study of McGrenere and Moore [33] we could derive upper and lower demand boundaries for features in text editing software. Without further data, these were assumed to be flat over time.

The resulting trajectory map (cf. Fig. 5) shows that the word processor of Google Docs fulfills all our criteria for a disruptive technology:

- The performance trajectory of Google Docs intersects the lower demand trajectory: Google Docs offers a “good enough” feature set for at least some customers.
- The performance trajectory of Microsoft Word overshoots the demand trajectory: Microsoft Word seems to be offering more features than utilized by its customers. Microsoft itself tried to improve the user interface in the most recent version, to make existing functionality more accessible [49].
- The performance trajectory of Google Docs shows a steep curve (fast attack on incumbent): Google managed to bring Docs to market with a “good enough” feature set from the start.

Table 7
Google Docs operations (German version of February 25, 2008).

Area of operation	Number of operations
Main screen	28
File menu	17
Style menu	8
Edit menu	2
Separator menu	6
Revisions	2
Print settings	8
Email document	11
Share screen	8
Publish screen	5
Comment menu	3
Insert hyperlink	9
Hyperlink menu	6
Insert table	13
Table menu	10
Insert bookmark	3
Insert symbol	2
Total	141

- The price trajectory of the PDI intersects the price trajectory of the established technology from above or stays always below: as Google Docs is offered free of charge, the price trajectory criterion was trivially fulfilled.

5. Discussion, conclusions and limitations

The trajectory maps for *storage capacity* (cf. Fig. 4) and *software features* (cf. Fig. 5) show, that the web applications we studied are already capable of satisfying market demand in established performance attributes. Although available data for Google Docs was limited to our initial feature analysis, the key finding in both trajectory maps was the rapid improvements that the PDI made in existing performance attributes. This suggests that web applications could offer desktop-like performance within the next years. The trajectory maps therefore indicate a disruptive technology.

Results from the criteria sheet are more mixed. While a foothold market entry for Google Docs is possible or already on its way, a main market entry seems to be blocked (cf. Fig. 3). The main obstacle are strong network effects, which favor Microsoft's products. Furthermore, Microsoft's main customers are still willing to pay for performance improvements along established criteria. However, the lock-in of the current user-base could possibly also provide an alternative explanation for the continuous acceptance of higher prices and additional features. Google's distinct business model and processes built around its web-based services amount to a clear disruptive threat. Microsoft has reacted by copying Google's product offerings and partly shifting its

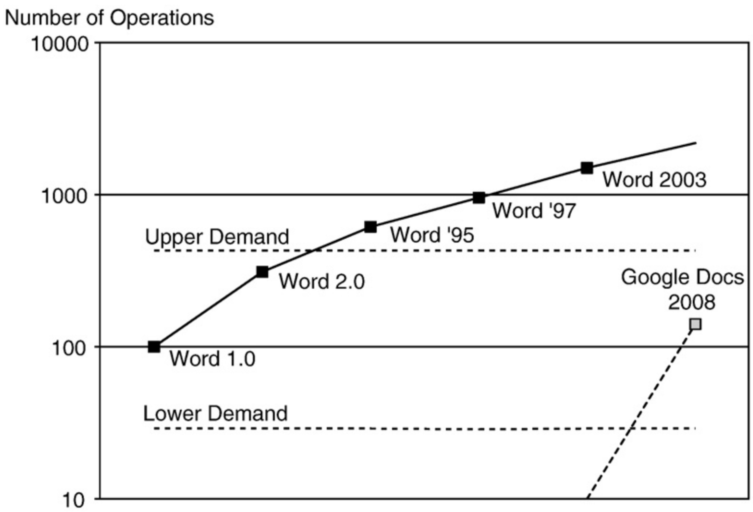

Fig. 5. Number of operations in text editing software.

business model. Although the success of this shift is unclear, the disruptive threat might be disabled in the main market entry phase, were Google Docs lacks so far the compatibility necessary to overcome coordination and switching costs. This could buy Microsoft the time that it needs to implement web applications technology by itself and avoid incumbent failure.

The results from the trajectory maps and the criteria sheet seem to contradict each other to a certain extent. Trajectory maps put the focus of analysis on product/technology performance and market demand. This matches the criteria considered in the *foothold market entry* phase of our criteria sheet. The results from this phase match the results from the trajectory maps: both signal a strong disruptive threat. While trajectory maps reveal the potential of the PDI to satisfy future market demand, the criteria sheet tests other resistances, like resources or network effects that could inhibit the disruption in the *main market entry* phase. It is in these aspects, that the results from trajectory maps and the criteria sheet start to diverge. Therefore, there is no contradiction between the chosen methods, rather, they complement each other for the understanding of the disruptive threat and should both be applied.

Our method is subject to a number of limitations. Deriving the disruptive potential ex ante requires studying the innovation while its effects unfold in the marketplace. The results we found are contingent on the decisions and further actions of Google and Microsoft [9] and might change over time [6].

The constructed trajectory maps singled out one performance attribute, while in reality complex trade-offs could exist between attributes, and many more relevant attributes could be found [7]. Further, the criteria on our sheet were weighted equally, and it remains unclear to which extent each criterion contributes to the disruptive threat of an innovation. Also, correlations could exist between the criteria. Lastly, whether an individual criterion is fulfilled or not could be subject to discussions all by itself. Further research is needed to determine the relative importance of individual aspects of disruptive innovations and refine the ex ante identification methods available to researchers.

However, our method unearthed critical success factors for the implementation of web applications technology that could be generalized for incumbents and entrants. Incumbents should build on existing network effects and strengthen them where possible, for example by sticking with proprietary standards. The time bought by customer inertia can then be used to match the entrants product offerings and develop simpler product versions for overshot market segments. Ideally, this should happen in an organization separate from the main business [9]. For entrants, the aim should be to differentiate their processes and business model as far as possible from incumbents, to make copying their products more difficult. Compatibility with the incumbent's file formats and products is a critical success factor. An alternative avenue might be to leverage the feature of web applications to operate above the level of a single device and target new markets, such as mobile computing. The latter aspect should be subject of future research.

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