



Analyse und Ökonomische Bewertung von Prozessflexibilität

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“TRUST YOURSELF,
BREAK SOME RULES,
DON'T BE AFRAID TO FAIL,
IGNORE THE NAYSAYERS,
WORK LIKE HELL, AND
GIVE SOMETHING BACK. “

*Dr. h.c. mult. Arnold Schwarzenegger
University of Southern California, May 15, 2009*

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Anmerkung: Eine fortlaufende Seitennummerierung wird pro Kapitel vorgenommen. Ein Literaturverzeichnis sowie die Anhänge werden jeweils am Ende eines jeden Kapitels aufgeführt.

Verzeichnis der Beiträge

In dieser Dissertation werden die folgenden veröffentlichten und zur Veröffentlichung angenommenen Beiträge vorgestellt:

B1 Krause, F. 2014. „Prozessflexibilisierung im Dienstleistungssektor,“ erscheint in *HMD - Praxis der Wirtschaftsinformatik*.

VHB JOURQUAL 2.1: 5,16 Punkte, Kategorie D

B2: Neuhuber, L., Krause, F., and Roeglinger, M. 2013. „Flexibilization of Service Processes: Toward an Economic Optimization Model,“ in *Proceedings of the 21st European Conference on Information Systems*, June 2013, Utrecht, Netherlands.

VHB JOURQUAL 2.1: 7,37 Punkte, Kategorie B

B3: Afflerbach P., Kastner G., Krause F., and Roeglinger M. 2014 „The Business Value of Process Flexibility – An Optimization Model and its Application in the Service Sector,“ erscheint in *Business & Information Systems Engineering* (6:4)

VHB JOURQUAL 2.1: 7,29 Punkte, Kategorie B

B4: Claus K., Krause F., and Ullrich, C. 2014 „Determining the Business Value of Volume Flexibility for Service Providers – A Real Options Approach,“ accepted for *22nd European Conference on Information Systems*, June 2014, Tel Aviv, Israel.

VHB JOURQUAL 2.1: 7,37 Punkte, Kategorie B

B5: Krause, F., Bewernik, M.A., and Fridgen, G. 2013. „Valuation of Manual and Automated Process Redesign from a Business Perspective,“ in *Business Process Management Journal* (19:1), pp. 95-110.

VHB JOURQUAL 2.1: 6,58 Punkte, Kategorie C

I Einleitung

Die heutige Marktsituation unterscheidet sich für die meisten Unternehmen drastisch von derjenigen vor zwei Jahrzehnten. So sehen sich Unternehmen mit einer steigenden Produktvielfalt (Alexopoulou et al. 2009; Kaluza and Blecker 2005) und gleichzeitig kürzer werdenden Produktlebenszyklen (Goyal and Netessine 2011) genauso konfrontiert wie mit einer stark individualisierten Nachfrage der Kunden (Kaluza and Blecker 2005). Die Gründe dafür liegen im gesellschaftlichen Wandel, der globalen Konkurrenz und rasanten Technologieentwicklungen. Insbesondere können im Bereich der Automatisierungstechnik und der Informations- und Kommunikationstechnologien schnelle Fortschritte beobachtet werden (Alexopoulou et al. 2009; Kaluza and Blecker 2005).

Diese Entwicklungen stellen Unternehmen mehr denn je vor die Herausforderung, unter einer unsicheren Marktentwicklung und sich wandelnden externen Rahmenbedingungen nachhaltig wirtschaftlich zu agieren (z.B. Hitt et al. 1998; Nandakumar et al. 2013; Schober and Gebauer 2011). Es ist daher kaum verwunderlich, dass Unternehmen, die sich nicht an neue Situationen anpassen, nicht lange im Markt bestehen können, oder anders ausgedrückt: „*change is crucial*“ (Sharfman and Dean Jr 1997). Dabei ist es zudem von enormer Bedeutung, dass Veränderung nicht ausschließlich als Reaktion auf neue Entwicklungen angestoßen wird, sondern auch proaktiv geplant wird, um im Falle von neuen Rahmenbedingungen bereits darauf vorbereitet zu sein (Kaluza and Blecker 2005).

Sowohl Wissenschaft als auch Praxis untersuchen diese Veränderungsfähigkeit unter dem Begriff der Flexibilität schon seit geraumer Zeit. Wie eingangs erwähnt, gewinnt dieses Thema vor dem Hintergrund der neuen Rahmenbedingungen noch weiter an Bedeutung (Schober and Gebauer 2011). Abgeleitet aus dem lateinischen „flexibilis“ wird „Flexibilität“ im allgemeinen Sprachgebrauch als 1. „flexible Beschaffenheit; Biegsamkeit, Elastizität“ und 2. „Fähigkeit des flexiblen, anpassungsfähigen Verhaltens“ verwendet (Duden 2014). Bartmann et al. (2011, S.2) konkretisieren diese Definition, indem sie Flexibilität als „das Potenzial eines Systems, auf Veränderungen im Inneren des Systems oder in seiner Umwelt durch zielorientierte Anpassung seines Verhaltens oder seiner Struktur zu reagieren und diese Veränderungen ggf. zu antizipieren“ bezeichnen. Übertragen auf den wirtschaftlichen Kontext kann damit die Fähigkeit eines Unternehmens bezeichnet werden, sich auf neue Gegebenheiten anzupassen und nach wie vor wirtschaftlich zu arbeiten.

Es besteht daher Einigkeit, dass Flexibilität eines der wichtigsten Themen für Unternehmen überhaupt ist (Alexopoulou et al. 2009; Hares and Royle 1993; Schober and Gebauer 2011; Weber et al. 2008). So wird seitens der Wissenschaft Flexibilität als „key area of value added“ (Hares and Royle 1993, p. 9) bezeichnet. Aus Praxissicht wird die Bedeutung der Flexibilität nicht minder beurteilt, was sich auch daran zeigt, dass sich „Business agility“ auf Platz 2 und „Time to Market / Velocity of Change“ auf Platz 6 der Top Themen des europäischen IT-Managements befinden (Derksen and Luftmann 2014).

Flexibilitätsforschung ist dabei kein neues Feld. Vielmehr wird Flexibilität schon seit fast 50 Jahren in wissenschaftlichen Publikationen untersucht (Bouncken and Bornewasser 2012). Dennoch besteht in diesem Rahmen weiterhin hoher Forschungsbedarf, da Flexibilität ein bislang unvollständig verstandenes Konzept darstellt (Chanopas et al. 2006; Mandelbaum and Buzacott 1990; Saleh et al. 2009). Da der Begriff Flexibilität als sehr vage gilt (Upton 1995), haben sich eine Vielzahl an Forschern daran versucht, Flexibilität zu verstehen und zu strukturieren (de Toni and Tochia 1998; Oke 2005; Saleh et al. 2009). Die daraus entstandene unüberschaubare Vielzahl an Definitionen erschwert jedoch das Verständnis von Flexibilität, da diese häufig feine Unterschiede aufweisen und sich auf unterschiedliche Anwendungsgebiete beziehen. So identifizieren Sethi und Sethi (1990) alleine 50 unterschiedliche Definitionen im Produktionsumfeld, während andere Autoren Flexibilität aus anderen Disziplinen wie der Dienstleistungsforschung heraus betrachten (siehe z.B. Fitzsimmons and Fitzsimmons 2010; Johnston et al. 2012). IS-Flexibilität als weitere Perspektive auf das Thema Flexibilität wird von Kumar und Stylianou (2014) vorgestellt. Die Autoren präsentieren dabei allein im IS-Umfeld insgesamt 30 verschiedene Flexibilitätstypen.

Ogleich eine Vielzahl von teils sehr spezifischen Definitionen zum Flexibilitätsbegriff existieren, können die meisten davon jedoch auf die beiden grundlegenden Arten Volumenflexibilität und inhaltliche Flexibilität zurückgeführt werden. Die Namensgebung dieser Flexibilitätsarten sind dabei unterschiedlich, so wird Volumenflexibilität auch als numerische Flexibilität und inhaltliche Flexibilität auch als (new) Product Flexibility bezeichnet (Johnston et al. 2012; OECD 1998). Dabei bezieht sich die Volumenflexibilität auf die Fähigkeit, auf geplante und ungeplante Nachfrageschwankungen nach bestehenden Produkten oder Dienstleistungen zu reagieren. Inhaltliche Flexibilität bezieht sich im Gegensatz dazu auf die Fähigkeit, mit ungeplanten oder einer großen Bandbreite an Kundenwünschen umzugehen, was sich sowohl darauf beziehen kann, bestehende Produkte und Dienstleistungen

anzupassen oder neu zu kombinieren als auch auf komplett neue Wünsche der Kunden reagieren zu können.

Betrachtet man Flexibilität im Rahmen des Unternehmensarchitekturmodells nach Buhl und Kaiser (2008) (siehe Abb. I-1), nimmt die Geschäftsprozessebene eine besondere Bedeutung ein. Das Unternehmensarchitekturmodell teilt die Architektur eines Unternehmens in die Ebenen Geschäftsmodell, Geschäftsprozesse, Anwendungssysteme und Infrastruktur ein.

Um flexibel auf unterschiedliche Veränderungen wie Nachfrageschwankungen reagieren zu können, den Bedarf an angepassten und neue Produkten / Dienstleistungen zu bedienen oder neue gesetzlichen Rahmenbedingungen umzusetzen, sind es letztendlich immer die Geschäftsprozesse, die flexibel sein müssen. Während das Geschäftsmodell eines Unternehmens zumindest nicht kurz- oder mittelfristig neu ausgerichtet wird, werden Anpassungen auf den Ebenen der Anwendungssysteme und der Infrastruktur durch neue oder veränderte Geschäftsprozesse erforderlich. So wird beispielsweise die Schwankung einer Kundennachfrage zunächst bei der Durchführung des entsprechenden Geschäftsprozesses merkbar. Dieser marktgetriebenen Anforderung kann mithilfe neuer Anwendungssysteme oder leistungsfähigerer Infrastruktur begegnet werden. Gleichzeitig ermöglichen Innovationen auf der Anwendungs- und Infrastrukturebene auch flexiblere Geschäftsprozesse, indem beispielsweise ein Workflow-Management-System das flexible Routing von Aufgaben durch einen Prozess ermöglicht. Infolgedessen verdient der Bereich der Prozessflexibilität besondere Aufmerksamkeit.

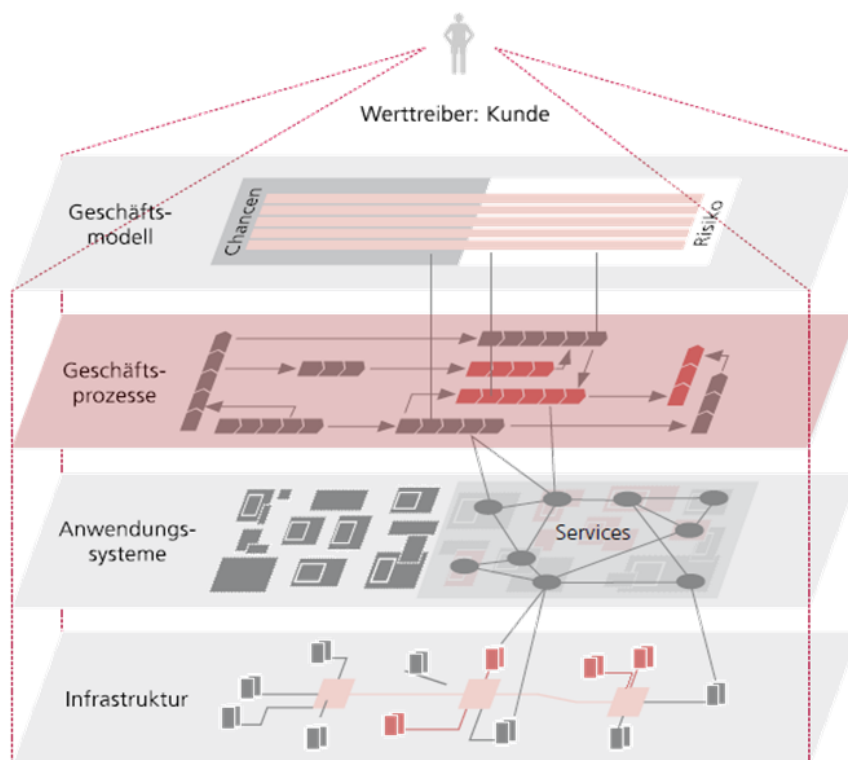


Abb. I-1: Ebenen einer Unternehmensarchitektur
(Buhl und Kaiser (2008))

Dabei stellt speziell im Bereich der Prozessflexibilität die Bestimmung des sinnvollen Flexibilitätsgrades eine besondere Herausforderung dar, die bislang nur unzureichend untersucht wurde (Aksin et al. 2008; Braunwarth and Ullrich 2010; Schonenberg et al. 2008). Auf der einen Seite existieren zwar einige Studien, die zum Ziel haben, die notwendigen Investitionen in Flexibilität zu bestimmen, jedoch basieren diese häufig auf subjektiven Methoden wie der Verwendung von Fragebögen oder der Einschätzung von Managern zur Situation ihrer Unternehmen und deren Bedingungen (Verdú-Jover et al. 2004, 2005; Lloréns et al. 2005). Auf der anderen Seite finden sich gerade im Bereich der Produktionsliteratur unzählige Rechenmodelle zur optimalen Auslastung von Produktionssystemen (siehe z.B. Aksin et al. 2008, He et al. 2012 oder Jordan and Graves 1995). Diese sind jedoch auf dieses spezielle Anwendungsgebiet beschränkt und beinhalten selten die Berücksichtigung ökonomischer Entscheidungsparameter wie Investitionsauszahlungen, erhöhte laufende Kosten für flexiblere Systeme oder prognostizierte Einzahlungserhöhungen durch Flexibilität.

Obwohl Prozessflexibilität zwar viele Vorteile mit sich bringt, sind ebenso Investitionen erforderlich, um das Flexibilitätsniveau der Prozesse zu heben. Intuitive Faustregeln, die davon

ausgehen, dass mehr Flexibilität immer von Vorteil ist, sind daher stark angreifbar (He et al. 2012). Vielmehr sind Methoden zur Entscheidungsunterstützung notwendig, um die Wahl der aus ökonomischen Sicht optimalen Investitionshöhe in Prozessflexibilität oder des aus ökonomischer Sicht idealen Flexibilitätsgrades zu unterstützen. Um entsprechende Bewertungssystematiken sinnvoll anzuwenden, ist eine Strukturierung des Bereichs Prozessflexibilität notwendig, da auch innerhalb des Teilbereichs Prozessflexibilität unterschiedliche Dimensionen existieren, die nach ihren spezifischen Charakteristika bewertet werden sollten.

Vor diesem Hintergrund widmet sich die vorliegende Dissertation diesen Forschungslücken und zeigt Erkenntnisse sowie weitere Ansatzpunkte für Wissenschaft und Praxis auf. Der nachfolgende Abschnitt I.1 enthält die Ziele und die Struktur der Dissertation, während im darauf folgenden Abschnitt I.2 die zugehörigen Forschungsbeiträge in den Forschungskontext eingebettet sowie die inhaltlichen Zusammenhänge der Beiträge detailliert erläutert werden. Zu diesem Zweck werden ebenfalls in Abschnitt I.2 die spezifischen Forschungsfragen der Beiträge dargelegt.

I.1 Zielsetzung und Aufbau dieser Dissertationsschrift

I. Einleitung	
Ziel I.1:	Darstellung der Zielsetzung und des Aufbaus der Arbeit
Ziel I.2:	Fachliche Einordnung und Motivation der zentralen Forschungsfragen
II. Überblick über Prozessflexibilität (B1)	
Ziel II.1:	Darstellung der Bedarfstreiber von Prozessflexibilität zur Strukturierung unterschiedlicher Dimensionen der Prozessflexibilität im Dienstleistungssektor
Ziel II.2:	Darstellung möglicher Maßnahmen zur Steigerung der Prozessflexibilität im Dienstleistungssektor
III. Bewertung von Prozessflexibilität (B2, B3, B4 und B5)	
Ziel III.1:	Identifikation des Zusammenhangs zwischen Prozessflexibilität und daraus resultierenden Cash-Inflows
Ziel III.2:	Ökonomisch fundierte Auswahl von Projekten zur Steigerung von inhaltlicher und Volumen-Prozessflexibilität im Dienstleistungssektor
Ziel III.3:	Entscheidungsunterstützung zur Auswahl der optimalen flexiblen Kapazität zwischen Prozessen zur Steigerung der Prozessflexibilität unter Berücksichtigung mehrerer Prozesse, expliziten Prozessfaktoren und einfacher Anwendbarkeit
Ziel III.4:	Ökonomische Bewertung der IT-gestützten Einbindung eines externen Partners als Maßnahme zur Steigerung der Volumenflexibilität unter der Berücksichtigung von indirekten Effekten auf den Kundenwert
Ziel III.5:	Ökonomische Bewertung von automatisiertem Prozess-Redesign als Maßnahme zur Steigerung der inhaltlichen Prozessflexibilität
Ziel III.6:	Vergleich von automatisiertem Prozess-Redesign mit manuellem Prozess-Redesign und Entscheidungsunterstützung zur Auswahl einer der Redesign-Alternativen
IV. Fazit und Ausblick	
Ziel IV.1:	Zusammenfassung der zentralen Erkenntnisse
Ziel IV.2:	Aufzeigen künftigen Forschungsbedarfs

Abb. I-2 Aufbau und Ziele der Dissertationsschrift

I.2 Fachliche Einordnung und fokussierte Forschungsfragen

Prozessflexibilität ist nach wie vor ein unreifes und nicht vollständig erschlossenes Themenfeld. Um Prozessflexibilität zielgerichtet und ökonomisch sinnvoll zu beeinflussen, ist es daher nötig, sich zunächst darüber klar zu werden, welche Treiber den Bedarf an Flexibilität bestimmen, d.h. welche Flexibilitätsdimension gesteigert werden sollte. Nur nach einer solchen vorgelagerten Betrachtung kann eine sinnvolle Auswahl an Maßnahmen zur Steigerung der betroffenen Dimension getroffen werden. So kann beispielsweise die Einführung oder Ausweitung von flexiblen Arbeitszeiten einer schwankenden Nachfragemenge gerecht werden, während dieselbe Maßnahme kaum Wirkung erzielt, wenn in kurzer Zeit Prozesse angepasst oder erstellt werden müssen. Nach der Identifikation der prinzipiell infrage kommenden Maßnahmen ermöglicht die ökonomische Bewertung dieser Maßnahmen im Einklang mit der wertorientierten Unternehmensführung (siehe hierzu z.B. Schultze und Hirsch 2005) eine Auswahl derjenigen Maßnahmen, die den höchsten Wertbeitrag generieren. Den Abschluss bildet schließlich die Operationalisierung der ausgewählten Maßnahmen. Da das Management von Prozessflexibilität nicht als einmaliger Vorgang betrachtet werden sollte, ist es sinnvoll, die genannten Schritte in regelmäßigen Abständen oder anlassbezogen (z.B. bei der Veränderung von externen Rahmenbedingungen) zu wiederholen. Der Fokus dieser Arbeit liegt dabei auf der Identifikation des Flexibilitätsbedarfs, der Identifikation geeigneter Maßnahmen (beides Beitrag 1) sowie der ökonomisch fundierten Bewertung und Auswahl der Maßnahmen (Beiträge 2, 3, 4 und 5). Die Vorgehensweise und der Fokus der Arbeit sind in Abb. I-3 visualisiert.

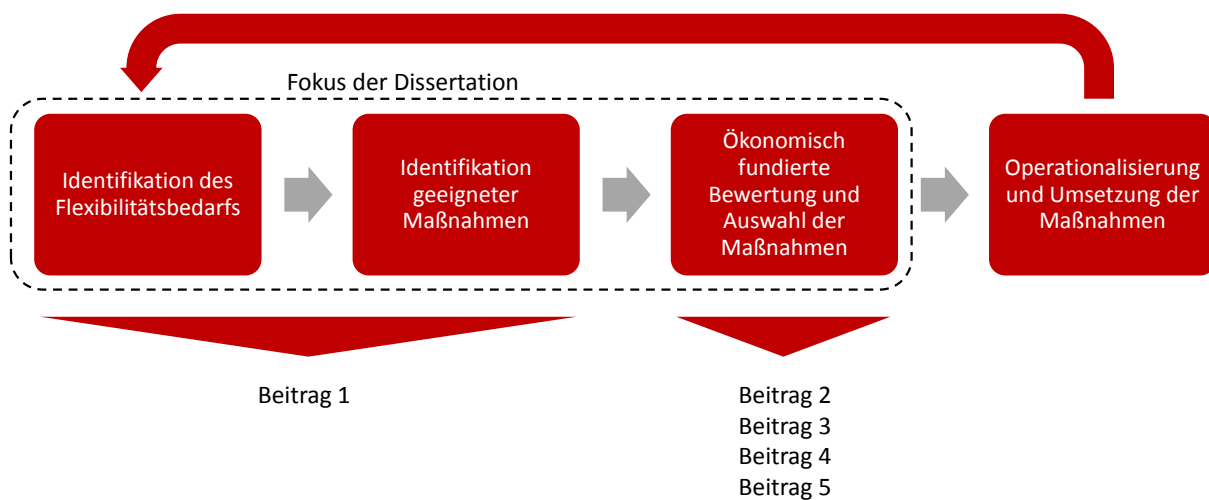


Abb. I-3 Fokus der Dissertationsschrift (eigene Darstellung)

I.2.1 Kapitel II: Überblick über Prozessflexibilität (Beitrag 1)

Dienstleistungsprozesse stehen vor der besonderen Herausforderung, dass die konstitutiven Eigenschaften von Dienstleistungen – insbesondere deren Nichtlagerbarkeit und Immaterialität sowie die Einbeziehung des Kunden in die Leistungserbringung – zu einem hohen Flexibilitätsbedarf führen. So müssen Dienstleistungen genau zu dem Zeitpunkt generiert werden können, zu dem sie nachgefragt werden, was die Anfälligkeit für Nachfrageschwankungen erhöht. Gleichzeitig erfordert die Einbeziehung des Kunden in die Leistungserbringung, dass Dienstleistungen tendenziell individueller erbracht werden und so Prozessänderungen in kurzer Zeit umgesetzt werden müssen. Diese Beispiele verdeutlichen, dass die konstitutiven Eigenschaften von Dienstleistungen die Identifikation von Bedarfstreibern der Prozessflexibilität im Dienstleistungsbereich erleichtern. Unstrukturierte und stark spezialisierte Dimensionen der Prozessflexibilität können anhand dieser Bedarfstreiber gruppiert werden, so dass der Flexibilitätsbedarf eines Unternehmens(teils) zielgerichtet bestimmt werden kann. Diese Notwendigkeit aufgreifend adressiert Beitrag 1 den in Abb. I-3 dargestellten Schritt „Identifikation des Flexibilitätsbedarfs“, indem basierend auf den konstitutiven Eigenschaften von Dienstleistungen vier Bedarfstreiber der Prozessflexibilität herausgearbeitet werden:

- Schwankende Nachfragemenge nach bestehenden Dienstleistungen,
- Änderungen in der Leistungserbringung bestehender Dienstleistungen,
- Neue oder veränderte Dienstleistungen sowie
- Änderungen bei eingebundenen Partnern.

Den Bedarfstreibern werden anschließend ähnliche Dimensionen der Prozessflexibilität zugeordnet, um bestehendes Wissen zu nutzen und gleichzeitig eine zielgerichtete Identifikation des Bedarfs zu ermöglichen. Um den in Abb. I-3 dargestellten zweiten Prozessschritt „Identifikation von geeigneten Maßnahmen“ zu adressieren, werden basierend auf den Dimensionen und Bedarfstreibern verschiedene Maßnahmen vorgestellt, die den Bedarf an Prozessflexibilität decken können. Um die Anwendung der Maßnahmen sowie deren Wirksamkeit besser zu verstehen, werden in Beitrag 1 spezifische Projekte aus der Praxis vorgestellt, welche bei weltweit agierenden Unternehmen mit dem Ziel der Steigerung der Prozessflexibilität durchgeführt wurden bzw. welche sich noch in der Umsetzungsphase befinden. Der Beitrag adressiert damit folgende Forschungsfragen:

-
- F. 1.1: *Welche Bedarfstreiber von Prozessflexibilität existieren im Dienstleistungssektor und wie können unterschiedliche Dimensionen der Prozessflexibilität mithilfe dieser Bedarfstreiber strukturiert werden?*
- F. 1.2: *Welche Maßnahmen können die Prozessflexibilität im Dienstleistungssektor erhöhen?*

I.2.2 Kapitel III: Modelle zur ökonomischen Bewertung von Bewertung von Prozessflexibilität (Beiträge 2, 3, 4 und 5)

Nachdem in Kapitel II die Bedarfstreiber von Prozessflexibilität vorgestellt und darauf basierend geeignete Maßnahmen zur Erhöhung von Prozessflexibilität erarbeitet wurden, fokussiert sich Kapitel III auf die ökonomische Bewertung von Investitionen in diese Maßnahmen, d.h. es handelt sich um Forschungsansätze zum dritten Prozessschritt aus Abb. I-3 „Ökonomisch fundierte Bewertung und Auswahl der Maßnahmen“. Eine tiefgehende Analyse dieser Thematik ist von besonderer Bedeutung, da die richtige Auswahl der Maßnahmen und somit der angemessene Grad an Prozessflexibilität sowohl von den internen Prozessbedingungen und den Umweltbedingungen der Unternehmung als auch von den positiven wie auch negativen ökonomischen Effekten der Maßnahmen abhängt (van Biesebroeck 2007). Dieser Forschungsbereich stellt sowohl für Wissenschaft als auch Praxis eine herausfordernde Aufgabe dar (Schober and Gebauer 2008).

Dabei werden unterschiedliche Dimensionen der Prozessflexibilität beleuchtet: Beitrag 2 adressiert auf einer abstrakteren Ebene sowohl inhaltliche als auch Volumenflexibilität aus einer Multiprojektperspektive. Die Beiträge 3 und 4 haben einen starken Fokus auf Volumenflexibilität und analysieren detailliert einzelne Projekte zu Steigerung der Prozessflexibilität. Beitrag 5 betrachtet im Gegensatz zu den Beiträgen 3 und 4 die Auswahl von mehreren Projekten zur Steigerung der inhaltlichen Flexibilität von Prozessen.

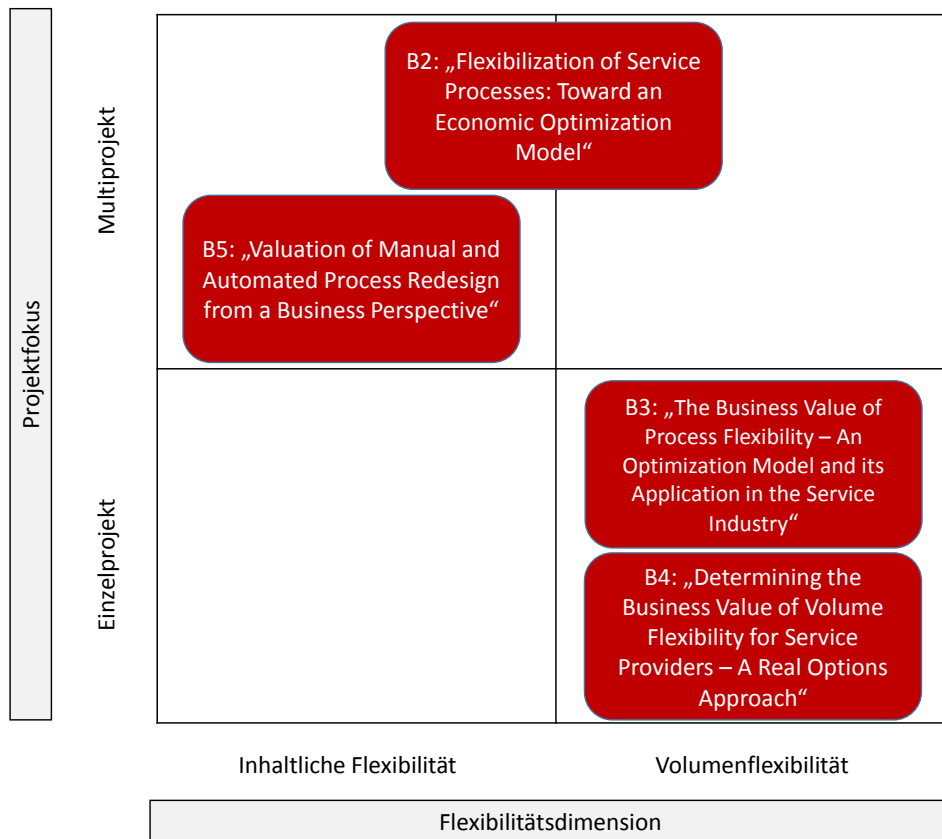


Abb. I-4 Fachliche Einordnung der Beiträge

Wie eingangs erwähnt existieren im Dienstleistungsbereich hohe Anforderungen an Prozessflexibilität. Dienstleister sehen sich häufig nicht nur schwankenden Nachfragemengen gegenüber, sie müssen auch unterschiedlichsten Anforderungen der Kunden nach angepassten und teilweise individualisierten Dienstleistungen gerecht werden. Damit wird deutlich, dass der ökonomischen Bewertung von Maßnahmen zur Steigerung der Prozessflexibilität von Dienstleistungsprozessen eine hohe Bedeutung beigemessen werden kann. Beitrag 2 nähert sich dieser Fragestellung und zeigt einen Zusammenhang zwischen Flexibilitätsinvestitionen und positiven ökonomischen Effekten auf. Um diese Verbindung herauszuarbeiten, wird insbesondere untersucht, wie sich die „total service time“, also die Zeit, die von der Anfrage eines Kunden bis zur vollständigen Erfüllung der Anfrage vergeht, von Flexibilitätsprojekten beeinflusst wird. Hierzu ist insbesondere die Klassifikation von auszuführenden Prozessinstanzen hilfreich, die in Runner, Repeater und Stranger unterteilt werden können (Johnston et al. 2012). Während Runner Instanzen in hoher Zahl nach standardisierten Dienstleistungen bezeichnen, beziehen sich Repeater zwar ebenfalls auf Standardanfragen, sind jedoch komplexer und werden seltener nachgefragt. In die Kategorie Stranger fallen schließlich alle hoch individualisierten Nachfragen, auf die ein Unternehmen nicht unmittelbar ohne

Vorbereitungszeit reagieren kann. Da je nach Kategorie unterschiedliche Maßnahmen zur Flexibilitätssteigerung notwendig sind, fokussiert sich das vorgestellte Optimierungsmodell nicht auf die Bewertung von Projekten zur Steigerung einer bestimmten Flexibilitätsdimension, sondern adressiert sowohl Projekte zur Steigerung von inhaltlicher wie auch von Volumenflexibilität von Prozessen.

Der Beitrag beantwortet dabei folgende Forschungsfragen:

F. 2.1: *Welcher Zusammenhang besteht zwischen Investitionen in Flexibilität und Cash-Inflows?*

F. 2.2: *Wie viel sollte ein Dienstleistungsanbieter in die Flexibilisierung seiner Dienstleistungsprozesse investieren?*

Um unterschiedliche Dimensionen der Flexibilität bewerten zu können, argumentiert Beitrag 2 aus einer abstrakten Perspektive. Darüber hinaus bleiben Flexibilitätseffekte *zwischen* verschiedenen Prozessen unberücksichtigt, da im Modell davon ausgegangen wird, dass die Durchführung eines Prozessflexibilitätsprojektes genau einen Prozess betrifft. Die Notwendigkeit einer detaillierteren Betrachtung wird von Beitrag 3 aufgegriffen. Dieser betrachtet explizit, wie ein Unternehmen die aus Marktsicht notwendige Volumenflexibilität herstellen kann, indem intern flexible Kapazität zur Verfügung gestellt wird. Diese ermöglicht, Kapazität zwischen unterschiedlichen Prozessen flexibel zu reallokieren. Hierbei wird sowohl Struktur und Verhalten der beteiligten Prozesse verändert, da neue Ausführungspfade in den flexibilisierten Prozessen generiert werden müssen. In diesem Setting präsentiert Beitrag 3 ein Optimierungsmodell, welches die monetären Faktoren einer Maßnahme der numerischen Flexibilität analysiert und darauf aufbauend eine Entscheidung zur optimalen flexiblen Kapazität zwischen den Prozessen ermöglicht. Insgesamt fokussiert Beitrag 3 damit die folgende Forschungsfrage:

F. 2.3: *Wie flexibel sollten die Prozesse eines Unternehmens sein, wenn positive und negative ökonomische Effekte berücksichtigt werden sollen und wenn Flexibilität aus einer Multi-Prozess-Perspektive betrachtet wird?*

Wie in Beitrag 1 dargestellt, können unterschiedliche Maßnahmen die Volumenflexibilität eines Unternehmens steigern. Nachdem Beitrag 3 untersucht, wie die flexible Reallokation von internen Kapazitäten die Volumenflexibilität steigern kann, kann auch die Einbindung eines externen Partners dazu dienen, Nachfragespitzen besser zu bewältigen (Aksin et al. 2008).

Während diese Möglichkeit im Produktionssektor schon länger gängige Praxis ist, ermöglichten erst neue Technologien wie Webservices, einheitliche Schnittstellen und Service-orientierte Architekturen die Einbindung von externen Anbietern auch im Dienstleistungsbereich (Häckel and Dorsch 2012; 2014). Dabei spielen insbesondere Service-orientierte Architekturen eine große Rolle, da die erleichterte Einbindung von Drittanbietern als einer der Hauptvorteile dieser Technologie gilt (Becker et al. 2011). Beitrag 4 adressiert diese Fragestellung und schlägt eine Methode vor, um zu bewerten, welchen ökonomischen Wert die durch eine IT-gestützte Einbindung eines externen Service-Anbieters gewonnene Flexibilität besitzt. Dabei beschränkt sich der Beitrag nicht allein auf die Betrachtung interner oder externer Verrechnungssätze zur Bearbeitung von Kundenanfragen. Es werden zudem auch indirekte Effekte wie negative Auswirkungen auf den Kundenwert berücksichtigt, sollte ein Unternehmen nicht in der Lage sein, Anfragen in der vom Kunden erwarteten Zeit bearbeiten können. Beitrag 4 beantwortet daher folgende Forschungsfrage:

F. 2.4: *Welchen Wert hat die Volumenflexibilität durch eine IT-gestützte Einbindung eines externen Service-Anbieters?*

Während sich die Beiträge 3 und 4 der Frage widmen, wie auf eine schwankende Nachfrage nach bestehenden Dienstleistungen reagiert werden kann, wird in Beitrag 5 der Fokus auf inhaltliche Flexibilität gelegt, d.h. die Möglichkeit, bestehende Prozesse an neue Rahmenbedingungen anzupassen oder neue Prozesse zu generieren. Dazu wird eine spezielle Maßnahme untersucht, um Prozessmodelle teilautomatisiert zu modellieren und mit der herkömmlichen manuellen Alternative aus einer ökonomischen Perspektive verglichen. Die untersuchte Maßnahme stammt aus dem Themenbereich des Semantic Business Process Management (SBPM) (Hepp et al. 2005) und basiert auf einer semantischen Annotation von möglichen Prozessaktionen, welche über einen Algorithmus je nach spezifiziertem Anfangs- und Zielzustand angeordnet werden müssen. In Beitrag 5 wird dabei davon ausgegangen, dass sowohl diese teilautomatisierte Lösung als auch die manuelle Modellierung von Prozessmodellen identische Lösungen generieren. Die Arbeit legt daher einen starken Fokus auf die Kostenaspekte, so dass das vorgestellte Optimierungsmodell die Berechnung der aus ökonomischer Sicht optimalen Investitionshöhe für die neue Technologie ermöglicht. Dabei untersucht Beitrag 4 die folgenden Forschungsfragen:

- F. 2.5: *Welche und wieviele Projekte zum Prozess-Redesign sollten basierend auf ihren Kosten, Erträgen und ihrem Projektumfang durchgeführt werden?*
- F. 2.6: *Wie hoch ist das obere Limit für Investitionen in automatisiertes Prozess-Redesign, so dass es aus ökonomischer Sicht manuellem Redesign überlegen ist?*

I.2.3 Kapitel IV: Ergebnisse und Ausblick

Abschließend werden in Kapitel IV die wesentlichen Erkenntnisse dieser Dissertationsschrift zusammengefasst sowie ein Ausblick auf künftigen Forschungsbedarf gegeben.

I.3 Literatur

- Aksin, O. Z., de Véricourt, F., and Karaesmen, F. 2008. „Call Center Outsourcing Contract Analysis and Choice,” in *Management Science* (54:2), pp. 354-368.
- Alexopoulou, N., Kanellis, P., Nikolaidou, M., and Martakos, D. 2009. „A Holistic Approach for Enterprise Agility,” in *Handbook of Research on Enterprise Systems*, Hershey, USA, IGI Global, pp. 1-18.
- Bartmann, D., Bodendorf, F., Ferstl, O.K., and Sinz, E.J. 2011. „Hochflexible Geschäftsprozesse,” in *Dienstorientierte IT-Systeme für hochflexible Geschäftsprozesse*, Bamberg, Germany, University of Bamberg Press, pp. 1-14.
- Becker, A., Buxmann, P. and Widjaja, T. 2011. „Value Potential and Challenges of Service-Oriented Architectures,” in *Business & Information Systems Engineering*, (3:4), pp.199-210.
- Bouncken, R.B.B., and Bornewasser M. 2012. *Flexibilität in Unternehmen Rahmenbedingungen und Perspektiven*. München, Germany, Rainer Hampp Verlag.
- Braunwarth, K. and Ullrich, C. 2010. „Valuating Business Process Flexibility Achieved through an Alternative Execution Path,” in *Proceedings of the 18th European Conference on Information Systems*, June 2010, Pretoria, South Africa.
- Buhl H.U., and Kaiser M. 2008. „Herausforderungen und Gestaltungschancen aufgrund von MiFID und EU-Vermittlerrichtlinie in der Kundenberatung,” in *Zeitschrift für Bankrecht und Bankwirtschaft* (20:1), pp. 43-51
- Chanopas, A., Krairit, D., and Khang, D. 2006. „Managing Information Technology Infrastructure: A New Flexibility Framework,” in *Management Research News* (29:10), pp. 632-651.
- De Toni, A., and Tonchia, S. 1998. „Manufacturing Flexibility: A Literature Review, ” in *International Journal of Production Research* (36:6), pp. 1587-1617.
- Derksen, B., and Luftman, J. 2014. „European Key IT and Management Issues & Trends for 2014,” <http://blog.cionet.com/2014/02/04/2014-european-it-management-trends/>, accessed 2014/08/04.
- Duden. 2014. <http://www.duden.de/rechtschreibung/Flexibilitaet>, accessed 2014/08/04.

-
- Fitzsimmons, J. A.; Fitzsimmons, M. J. 2010. *Service Management: Operations, Strategy, Information Technology*, New York, USA, McGraw-Hill.
- Goyal, M., and Netessine, S. 2011. „Volume Flexibility, Product Flexibility, or Both: The Role of Demand Correlation and Product Substitution,” in *Manufacturing and Service Operations Management* (13:2), pp. 180-193.
- Häckel, B., and Dorsch, C. 2012. „Integrating Business Partners on Demand: The Effect on Capacity Planning for Cost Driven Support Processes,” in *Proceedings of the 45th Hawaii International Conference on System Sciences*, January 2012, Maui, USA, pp.4796-4805.
- Häckel, B. and Dorsch, C. 2014. „Combining Models of Capacity Supply to Handle Volatile Demand: The Economic Impact of Surplus Capacity in Cloud Service Environments,” in *Decision Support Systems* (58:2), pp. 3-14.
- Hares, J., Royle, D. 1994. *Measuring the Value of Information Technology*, Chichester, Great Britain, Wiley.
- He P., Xu, X., and Hua, Z. 2012. „A New Method for Guiding Process Flexibility Investment: Flexibility Fit Index,” in *International Journal of Production Research* (50:14), pp. 3718-3737.
- Hepp, M., Leymann F., Domingue J., Wahler A., and Fensel D. 2005. „Semantic Business Process Management: A Vision towards Using Semantic Web Services for Business Process Management,” *Proceedings of the IEEE International Conference on e-Business Engineering*, October 2005, Beijing, China, pp. 535-540.
- Hitt M., Keats B., and DeMarie S. 1998. „Navigating in the New Competitive Landscape: Building Strategic Flexibility and Competitive Advantage in The 21st Century,” in *Academy of Management Executive* (12:4), pp. 22–43
- Johnson, M., Selnes, F. 2004. „Customer Portfolio Management: Toward a Dynamic Theory of Exchange Relationships,” in *Journal of Marketing* (68:2), pp. 1-17.
- Kaluza, B., and Blecker, T. 2005. *Erfolgsfaktor Flexibilität: Strategien und Konzepte für wandlungsfähige Unternehmen*, Berlin, Germany, Erich Schmidt Verlag GmbH & Co

-
- Kumar, R. L., and Stylianou, A. C. 2013. „A Process Model for Analyzing and Managing Flexibility in Information Systems,” in *European Journal of Information Systems* (23:2), pp. 151-184.
- Lloréns, F. J., Molina, L. M., and Verdú, A. J. 2005. „Flexibility of Manufacturing Systems, Strategic Change, and Performance,” in *International Journal of Production Economics*, (98:3), pp. 273–289.
- Mandelbaum, M., and Buzacott, J. A. 1990. „Flexibility and Decision Making,” in *European Journal of Operations Research* (44:1), pp. 17-27.
- Nandakumar, M.K., and Jharkharia, S., and Nair, A. 2013. „Environmental Uncertainty and Flexibility,” in *Global Journal of Flexible Systems Management* (13:3), pp. 121-122.
- OECD (1998). *The Challenge of Measuring and Evaluating Organisational Change in Enterprises*, OECD, Paris.
- Oke, A. 2005. „A Framework for Analysing Manufacturing Flexibility,” in *International Journal of Operations and Production Management* (25:10), pp. 973-996.
- Saleh, J. H., Mark, G., and Jordan, N. C. 2009. „Flexibility: A Multi-Disciplinary Literature Review and a Research Agenda for Designing Flexible Engineering Systems,” in *Journal of Engineering Design* (20:3), pp. 307-323.
- Sharfman, M. P., and Dean Jr, J. W. 1997. „Flexibility In Strategic Decision Making: Informational and Ideological Perspectives,” in *Journal of Management Studies*, (34:2), pp. 191-217.
- Schober, F., and Gebauer, J. 2011. „How Much to Spend on Flexibility Determining the Value of Information System Flexibility,” in *Decision Support Systems* (51:3), pp. 638-647.
- Schonenberg, H., Mans, R. S., Russell, N. C., Mulyar, N. A., and van der Aalst, W. M. P. 2008. „Process Flexibility: A survey of Contemporary Approaches,” in *Advances in Enterprise Engineering*, Berlin, Germany, Springer, pp. 16-30.
- Schultze, W., and Hirsch, C. 2005. *Unternehmenswertsteigerung durch Wertorientiertes Controlling*, München, Germany, Vahlen.
- Sethi, A., and Sethi, S. 1990. „Flexibility in Manufacturing: A Survey,” in *International Journal of Flexible Manufacturing Systems* (2:4), pp. 289-328.

-
- van Biesebroeck, J. 2007. „The Cost of Flexibility,” in *Assembly Automation* (27:1), pp. 55-64.
- Verdú-Jover, A. J., Lloréns-Montes, F. J., and García-Morales, V. J. 2004. „The Concept of Fit in Services Flexibility Research: An Empirical Approach,” in *International Journal of Service Industry Management*, (15:5), pp. 499-514.
- Verdú-Jover, A. J., Lloréns-Montes, J. F., and García-Morales, V. J. 2005. „Flexibility, Fit and Innovative Capacity: An Empirical Examination,” in *International Journal of Technology Management*, (30:1), pp. 131-146.
- Weber, B., Reichert, M., and Rinderle-Ma, S. 2008. „Change Patterns and Change Support Features – Enhancing Flexibility in Process-Aware Information Systems,” in *Data and Knowledge Engineering*, (66:3), pp. 438-466.

II Überblick über Prozessflexibilität

II.1 Beitrag 1: „Prozessflexibilisierung im Dienstleistungssektor“

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Zusammenfassung

Dienstleister stehen mehr denn je unter Druck, da sie in der Lage sein müssen, flexibel auf sich verändernde Umweltbedingungen reagieren zu können. Dies erfordert Prozessflexibilität. Typische Bedarfstreiber sind z.B. schwankende Nachfragemengen, Änderungen in der Leistungserbringung oder Änderungen bei den eingebundenen Partnern. Auf diese kann mit Maßnahmen zur Flexibilitätssteigerung wie Automatisierung, Zeitarbeit, Multi-Skilling, Alternativen im Prozessmodell, Unterspezifikation, Modularisierung oder Multi-Sourcing reagiert werden. Anhand konkreter Beispiele aus Interviews mit Entscheidungsträgern aus einem Telekommunikations- und einem Versicherungsunternehmen werden Erfahrungen und Lessons Learned aus der Praxis aufgezeigt.

II.1.1 Dienstleister unter Druck

Der Dienstleistungssektor gehört zu den am stärksten wachsenden Wirtschaftsbereichen. So stellt die OECD fest, dass 74% der Arbeitnehmer in Deutschland im Dienstleistungssektor beschäftigt sind und dass dieser für 71% des Bruttoinlandsproduktes (USA: ca. 80%) verantwortlich ist (OECD Publishing 2012). Dienstleistungen unterscheiden sich dabei maßgeblich von Sachgütern. So sind Dienstleistungen immateriell, d.h. nicht lagerbar, Kunden sind in den Leistungserstellungsprozess eingebunden und die Qualität von Dienstleistungen wird häufig von Dienstleister und Kunde unterschiedlich wahrgenommen (Leimeister 2012).

Aus diesen Eigenschaften und sich ständig ändernden Umweltbedingungen wie schwankende Nachfragemengen, wechselnde Kundenbedürfnisse und neue gesetzliche Vorgaben ergibt sich ein starker Druck für Dienstleister, sich schnell an neue Erfordernisse anzupassen. So verwundert es nicht, dass laut einer internationalen Studie „business agility“ und „speed to market“ auf Platz 2 der Anliegen des Top IT Managements liegen (Luftman et al. 2012).

Um den tatsächlichen Flexibilitätsbedarf zu analysieren, ist eine Untersuchung der Rahmenbedingungen des Unternehmens unabdingbar. Dadurch lassen sich Bedarfstreiber gliedern und klar darlegen. Diese Struktur erleichtert es, aus der nahezu unüberschaubaren Anzahl an Definitionen von Flexibilität diejenige zu identifizieren, die tatsächlich gesteigert werden soll. Ist der Bedarf identifiziert, bleibt zudem oftmals unklar, wie die Flexibilität von Dienstleistungsprozessen gesteigert werden kann, da Maßnahmen zur Flexibilitätssteigerung in der wissenschaftlichen Literatur einzeln zwar detailliert analysiert werden, jedoch nicht einem bestimmten Bedarfstreiber zugeordnet werden.

II.1.2 Bedarfstreiber der Prozessflexibilität

Flexibilität bezeichnet speziell für Unternehmen, sich an Änderungen anzupassen und nach wie vor wirtschaftlich zu arbeiten. Dabei spielt Prozessflexibilität eine besondere Rolle für Unternehmen. Um flexibel auf unterschiedliche Rahmendbedingungen reagieren zu können, sind es letztendlich immer die Prozesse, welche flexibel reagieren müssen. Während das Geschäftsmodell eines Unternehmens zumindest nicht kurz- oder mittelfristig neu ausgerichtet wird, haben Anpassungen an Anwendungssystemen und der Infrastruktur immer eine verbesserte Prozessunterstützung zum Ziel. Die Bedeutung der Prozessflexibilität ist gerade für die Wirtschaftsinformatik von hoher Bedeutung, da die Prozesse eines Unternehmens die Schnittstelle zwischen den oft technisch getriebenen Ebenen der Hard- & Software und des betriebswirtschaftlich getriebenen Geschäftsmodells bilden.

Im Folgenden werden daher vier Bedarfstreiber vorgestellt, die verschiedene Definitionen der Prozessflexibilität bündeln. Die Identifikation dieser Bedarfstreiber basiert auf den konstitutiven Merkmalen von Dienstleistungen, da diese eine gute Strukturierungshilfe für die Rahmenbedingungen von Dienstleistern bilden. Die Merkmale von Dienstleistungen, die Bedarfstreiber der Prozessflexibilität sowie die den Bedarfstreibern zugeordneten Maßnahmen zur Steigerung der Prozessflexibilität finden sich in Abbildung 1.

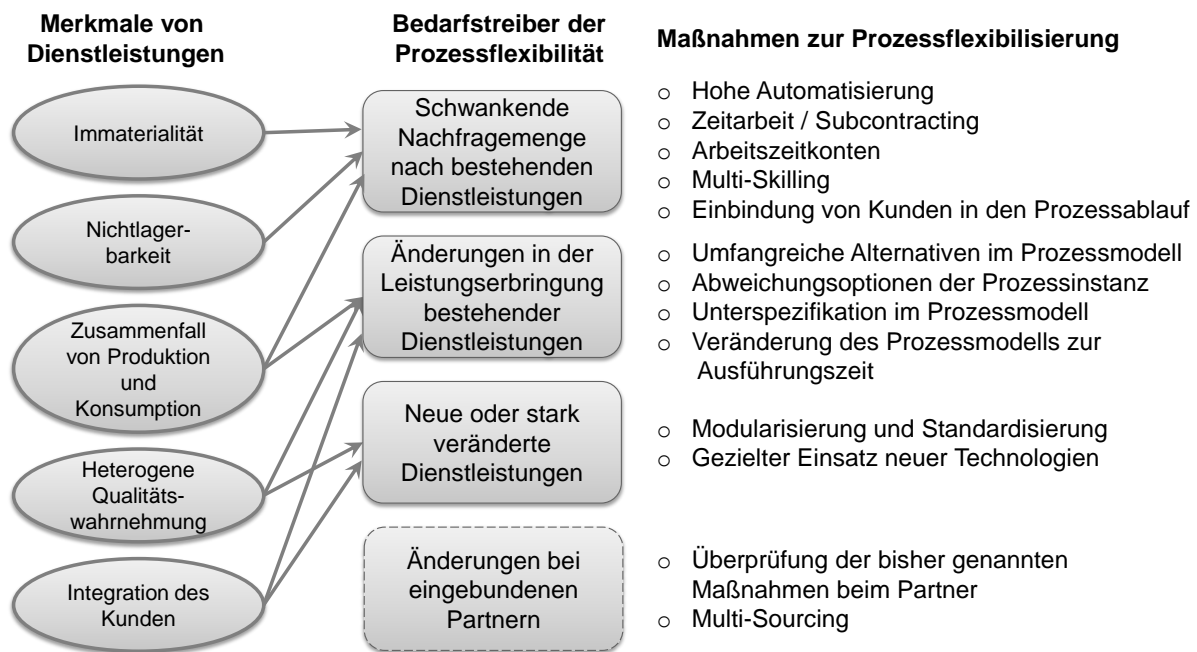


Abb. II-1 Zusammenhang zwischen Dienstleistungsmerkmalen, Flexibilitätstreibern und Umsetzungsmaßnahmen

Die vorgestellten Flexibilitätstreiber bündeln dabei ähnliche Definitionen der Prozessflexibilität, um deren hohe Anzahl zu strukturieren und somit die Möglichkeit zu schaffen, zielgerichtete Maßnahmen zur Steigerung der Prozessflexibilität aufzuzeigen.

- Schwankende Nachfragemenge nach bestehenden Dienstleistungen

Da Dienstleistungen nicht auf Vorrat produziert werden können, sondern durch ihre Immaterialität immer genau dann erbracht werden müssen, wenn Sie nachgefragt werden, müssen Unternehmen speziell im Dienstleistungssektor in der Lage sein, unterschiedliche Nachfragemengen nach bestehenden Dienstleistungen schnell bedienen zu können. Ein Unternehmen ist daher umso flexibler, je eher es den Dienstleistungsprozess auf die neuen Nachfragemengen anpassen kann, um weiterhin wirtschaftlich zu arbeiten. Diese Art der Flexibilität wird als Volumenflexibilität bezeichnet. Volumenflexibilität bedeutet insbesondere, dass in Zeiten von hoher Nachfrage übermäßige Wartezeiten für Kunden und somit negative Mund-zu-Mund Propaganda vermieden werden muss. Gleichzeitig kann eine überhöhte Kapazität in Zeiten von niedriger Nachfrage hohe Leerkosten verursachen. Planbare Änderung der Nachfrage treten etwa bei saisonalen Effekten wie stürmischen Jahreszeiten bei Versicherern oder Schulferien bei Reiseveranstaltern auf. Nachfrageschwankungen, die nur schwer planbar sind, können dagegen oftmals auf externe

Einflüsse zurückgeführt werden. So können negative Pressemeldungen über Arbeitsbedingungen von Mitarbeitern im Ausland die Nachfrage kurzzeitig einbrechen lassen, oder eine Havarie eines Kreuzfahrtschiffes die Nachfrage nach entsprechenden Pauschalreisen einer ganzen Branche negativ beeinflussen.

- Änderungen in der Leistungserbringung bestehender Dienstleistungen

Da Kunden im Leistungserstellungsprozess von Dienstleistungen direkt eingebunden sind, die erbrachte Dienstleistung jedoch immer subjektiven Bewertungen unterliegt, treten häufig unerwartete Anpassungen in der Leistungserbringung bestehender Dienstleistungen auf. Für Unternehmen ist es essentiell, dynamisch darauf reagieren zu können. Man spricht dabei von Modification Flexibility, eine sich auf bestehende Dienstleistungen beziehende Form der inhaltlichen Flexibilität. So können Prozessschritte wiederholt auszuführen sein, bestimmte Prozessschritte übersprungen oder ungeplante, bisher nicht vorhandene Prozessschritte notwendig werden. Zwei Beispiele verdeutlichen diesen Bedarf. Zum einen kann sich ein Reiseveranstalter damit konfrontiert sehen, dass ein Kunde zusätzlich zu einer Reise nach Wien Operntickets reservieren möchte. Zum anderen sind in einem Krankenhaus sofort lebensrettende Maßnahmen einzuleiten, falls während einer medizinischen Standardbehandlung ein Notfall auftritt, ohne dass die bislang geplanten Schritte vorher zu Ende geführt werden müssen.

- Neue oder stark veränderte Dienstleistungen

Die Erfordernis, neue oder stark veränderte Dienstleistungen in Prozesse umzusetzen, deckt sich stark mit den Anforderungen an das produzierende Gewerbe, weshalb die unterschiedlichen Dimensionen der Prozessflexibilität aus diesem Bereich entnommen und adaptiert werden können. Im Dienstleistungssektor verstärkt die Einbindung des Kunden in den Leistungserstellungsprozess sowie die unterschiedliche Qualitätswahrnehmung zudem nochmals den Bedarf an Flexibilität. Diese inhaltliche Dimension wird durch Produktflexibilität adressiert. Das Kernelement dieses Begriffs ist die Fähigkeit eines Unternehmens, seine Produktbandbreite an sich ändernde Marktanforderungen anzupassen. Dabei können verschiedene Subkategorien unterschieden werden: so spricht man beispielsweise von New Product Flexibility, wenn die Zeitspanne gemessen werden soll, in

der ein Unternehmen komplett neue Produkte vom Ideenstatus bis hin zur Markteinführung bringt.

- **Änderungen bei eingebundenen Partnern**

Sind im Dienstleistungsprozess mehrere Unternehmen beteiligt, so müssen diese in der Bewertung des Flexibilitätsbedarfs ebenfalls berücksichtigt werden. Ist auch nur ein eingebundener Partner unflexibel in Bezug auf die bislang beschriebenen Flexibilitätsdimensionen, kann dies die schnelle Reaktion auf Änderungen verhindern. Dies ist auch dann der Fall, wenn das eigene Unternehmen bereits umfassende Investitionen in Prozessflexibilität getätigt hat.

II.1.3 Maßnahmen zur Steigerung der Prozessflexibilität

Im Folgenden wird ein Überblick über mögliche Maßnahmen zur Steigerung der Prozessflexibilität gegeben. Dabei sind die vorgestellten Maßnahmen bewusst abstrakt gehalten, da sie basierend auf den Flexibilitätstreibern eines Unternehmens (siehe vorhergehendes Kapitel) Anregungen für weitere Schritte zur Flexibilitätssteigerung in der ausgewählten Dimension aufzeigen sollen. Erscheint eine vorgestellte Maßnahme passend für ein Unternehmen, so ist es unumgänglich, diese tiefer mithilfe von weitergehender Literatur und Praxiserfahrungen zu analysieren und z.B. mithilfe von Pilotprojekten zu operationalisieren.

Um die genannten Maßnahmen zu strukturieren, sind diese einzelnen Bedarfstreibern zugeordnet. Sollte eine Maßnahme mehrere Flexibilitätstreiber betreffen, so wurde sie demjenigen Flexibilitätstreiber zugeordnet, bei dem sie ihre Hauptwirkung entfaltet.

II.1.3.1 Schwankende Nachfragemenge nach bestehenden Dienstleistungen

Strategien, um auf eine schwankende Nachfrage zu reagieren, zielen in erster Linie auf die Reduzierung von Fixkosten ab. Darüber hinaus kann ein Lastenausgleich durch eine breite Befähigung der Mitarbeiter erreicht werden, um so Nachfragespitzen abzufangen (Fitzsimmons u. Fitzsimmons 2010)

II.1.3.1.1 Hohe Automatisierung

Hohe Automatisierungsgrade in Dienstleistungsprozessen erlauben, flexibler auf Nachfragespitzen zu reagieren als dies mithilfe einer Konzentration auf Mitarbeiter möglich ist. Dabei bleiben die entstandenen Leerkosten bei unerwartet niedriger Nachfrage in der Regel niedriger als bei Mitarbeitern, deren Lohn sich zum Großteil nach der Anwesenheitszeit richtet. Die Ausprägungen der Automatisierung sind vielfältig: Betriebliche Standardsoftware wie SCM-, ERP- oder CRM-Systeme ermöglichen es, bislang manuell ausgeführte Prozessschritte automatisiert auszuführen. Eigenentwickelte Anwendungssysteme ermöglichen die Änderung von Geschäftsprozessen, um damit einer schwankenden Nachfrage Herr zu werden (siehe auch 4.6 Modularisierung und Standardisierung im Versicherungsbereich). Weiterhin unterstützen Workflow-Management-Systeme (WFMS) Geschäftsprozesse, um die Aufgabensteuerung effizient zu automatisieren und Mitarbeiter dabei zu unterstützen, teilautomatisierbare Aufgaben auszuführen

II.1.3.1.2 Zeitarbeit / Subcontractor

In Zeiten von hoher Nachfrage kann ein Unternehmen temporär Mitarbeiter anstellen, die nur in der Zeitperiode beschäftigt sind, in der sie aus Kapazitätssicht benötigt werden. Die Vernetzung von Unternehmen in der Cloud erlaubt dabei, Arbeitskraft kurzfristig und skalierbar über eine Anbindung an eine „Human Cloud“ zur Verfügung zu stellen (Kaganer et al. 2013). Hierbei ist jedoch darauf zu achten, dass Zeitarbeiter unter Umständen geringes firmenspezifisches Wissen haben und eine Einarbeitungsphase benötigen. Eine weitere Möglichkeit stellt die kurzfristige Einbindung von Unternehmen dar, die darauf spezialisiert sind, Nachfrageüberhänge abzufangen. Ist die technische und vertragliche Möglichkeit dieses „Peak-loppings“ geschaffen, kann dies auch kurzfristig zu einer deutlichen Entlastung führen. Der Anbieterwechsel muss dabei für die Kunden nicht erkennbar sein – beispielsweise bei Callcentern oder Service-Anbietern, die kurzfristig Rechenkapazität zur Verfügung stellen können.

II.1.3.1.3 Arbeitszeitkonten

Arbeitszeitkonten erlauben es, durch Nachfragespitzen aufgebaute Überstunden in Zeiten von niedriger Nachfrage abzubauen – ohne zusätzliche Kosten für das Unternehmen. Die Verbreitung von Arbeitszeitkonten hat in den vergangenen Jahren laut einer Studie des Nürnberger Instituts für Arbeitsmarkt- und Berufsforschung stark zugenommen: So verfügt heute

fast jeder zweite Arbeitnehmer über ein Arbeitszeitkonto (Zapf 2012). Die durch Arbeitszeitkonten gewonnene Volumenflexibilität richtet sich dabei nach der Konfiguration der Konten: So kann eine zu niedrige Grenze für sammelbare Überstunden die Wirksamkeit des Instruments hemmen. Gleichzeitig ist auch die Gültigkeitsdauer der Überstunden von Bedeutung. Müssen Überstunden innerhalb nur weniger Monate abgearbeitet werden, besteht die Gefahr, dass der Flexibilitätseffekt schnell verpufft.

II.1.3.1.4 Multi-Skilling

Durch Multi-Skilling-Maßnahmen werden Mitarbeiter befähigt, mehrere unterschiedliche Aufgaben auszuführen und/oder in mehreren Dienstleistungsprozessen mitzuwirken. Durch eine Erweiterung der Fähigkeiten von Mitarbeitern ist es so möglich, sie bei Nachfragespitzen zur Unterstützung heranzuziehen, sofern in einem anderen Prozess eine niedrigere Auslastung herrscht. Somit sind Teams von breiter ausgebildeten Mitarbeitern in der Regel reinen Spezialistenteams überlegen (Easton 2011). Sollten Mitarbeiter jedoch mit zu vielen unterschiedlichen Aufgaben betraut sein, kann die Qualität der Aufgabenerfüllung leiden. Dieser Trade-Off kann jedoch durch eine geeignete IT-Unterstützung von breiter qualifizierten Mitarbeitern (z.B. durch Wissensmanagementsysteme oder Workflow-Management-Systeme) abgemildert werden.

II.1.3.1.5 Einbindung von Kunden in den Prozessablauf

Durch die Einbindung von Kunden in den Leistungserstellungsprozess kann Kapazität genau zu dem Zeitpunkt bereitgestellt werden, zu dem sie benötigt wird. Ein prominentes Beispiel für Kundenintegration in Dienstleistungsprozesse sind Fast-Food-Ketten, in denen die Kunden ihre Tische selbst abräumen. Insbesondere eignen sich zudem Online-Dienste, Kunden in den Prozessablauf einzubinden. Aus Unternehmenssicht entfällt so beispielsweise beim Online-Bezug von Versicherungsdienstleistungen die gesamte Datenaufnahme des Kunden. Risiken liegen dabei in der eingeschränkten Möglichkeit, die Qualität des entsprechenden Prozessabschnitts sicherzustellen. Letztendlich liegt die Herausforderung darin, die Handlungsmöglichkeiten der Kunden auf die notwendigen Prozessschritte zu beschränken und gleichzeitig Anreize zu setzen, diese auch korrekt auszuführen.

II.1.3.2 Änderungen in der Leistungserbringung bestehender Dienstleistungen

Um einen flexiblen Prozessablauf schon bei der Prozessdefinition sicherzustellen, ergeben sich vier grundsätzliche Möglichkeiten (Schonenberg et al. 2008). Diese Möglichkeiten stehen nicht allein bei einer manuellen Prozessausführung zur Verfügung, sondern sind auch beim Einsatz

von WFMS hochrelevant. So hat der ausführende Mitarbeiter (oder Kunde, siehe „Integration vom Kunden in den Prozessablauf“) auch bei entsprechender IT-Unterstützung auf die Prozessänderung zu reagieren, indem er beispielsweise eine andere Maske im System aufruft, obwohl diese erst zu einem späteren Zeitpunkt zugänglich wäre.

II.1.3.2.1 Umfangreiche Alternativen im Prozessmodell

Um einen flexiblen Prozessablauf schon bei der Prozessdefinition sicherzustellen, ergeben sich vier grundsätzliche Möglichkeiten (Schonenberg et al. 2008). Diese Möglichkeiten stehen nicht allein bei einer manuellen Prozessausführung zur Verfügung, sondern sind auch beim Einsatz von WFMS hochrelevant. So hat der ausführende Mitarbeiter (oder Kunde, siehe „Integration vom Kunden in den Prozessablauf“) auch bei entsprechender IT-Unterstützung auf die Prozessänderung zu reagieren, indem er beispielsweise eine andere Maske im System aufruft, obwohl diese erst zu einem späteren Zeitpunkt zugänglich wäre.

II.1.3.2.2 Temporäre Abweichungsoptionen der Prozessinstanz

Um an konkreten Prozessschritten eine temporäre Abweichung vom vorgegebenen Prozessablauf zu erlauben, können diese Prozessschritte zur Design Time entsprechend gekennzeichnet werden. Diese Kennzeichnung erlaubt dabei unterschiedliche Abweichungen: Prozessschritt rückgängig machen, Prozessschritt erneut ausführen, Prozessschritt überspringen oder späteren Prozessschritt als nächstes ausführen.

II.1.3.2.3 Unterspezifikation im Prozessmodell

Werden bestimmte Prozessabschnitte nur grob spezifiziert und mit einem Hinweis versehen, dass hier Abweichungen möglich sind, kann diese „Unterspezifikation“ eine flexiblere Ausführung des Prozesses gewährleisten. So wird dem ausführenden Mitarbeiter nicht nur die Freiheit gegeben, selbst zu entscheiden, wie dieser vorab festzulegende Prozessschritt im Detail auszuführen ist, sondern es können auch durch ein Tracking der individuellen Ausführung neue Pfade für ein Prozessmodell definiert werden. Im Zusammenhang mit WFMS erlaubt die Unterspezifikation von Prozessmodellen zudem, unvollständige Prozessmodelle auszuführen und zur Ausführungszeit (Run Time) die fehlenden Abschnitte aus einer vordefinierten Bibliothek an Prozessfragmenten je nach Bedarf zu ergänzen.

II.1.3.2.4 Dauerhafte Veränderung des Prozessmodells zur Ausführungszeit

Während sich die beiden letzten vorgestellten Maßnahmen darauf beziehen, temporär vom vorgesehenen Prozesspfad abzuweichen, bezieht sich diese Methode darauf, das Prozessmodell an sich zur Ausführungszeit anzupassen. Dies kann notwendig werden, wenn Änderungen nicht vom Prozesseigner ausgehen, sondern direkt vom ausführenden Mitarbeiter. Dieser bemerkt solche Änderungen in der Regel während seiner täglichen Arbeit und lässt die Änderung vom Prozesseigner genehmigen. Ein Beispiel kann hier die Änderung der Reihenfolge von zwei voneinander unabhängigen Prozessschritten aus Praktikabilitätsgründen sein.

II.1.3.3 Neue oder veränderte Dienstleistungen

II.1.3.3.1 Modularisierung und Standardisierung

Während die komplette Standardisierung einer Dienstleistung oft die Änderungsflexibilität eines Unternehmens hemmt, kann ein modularer Aufbau mithilfe von standardisierten Komponenten ein geeignetes Mittel darstellen, um auf sich ändernde Anforderungen zu reagieren. So können einzelne Module verändert werden, ohne die anderen Teilmodule zu beeinflussen. Weiterhin kann über eine neue Zusammensetzung der bestehenden Teilkomponenten eine komplett neue Dienstleistung geschaffen werden. Durch die Hinzunahme von neuen Teilmodulen können bestehende Dienstleistungen erweitert oder neue Dienstleistungen angeboten werden. Gerade bei hochindividuellen Dienstleistungen stößt diese Maßnahme jedoch an ihre Grenzen, da nicht jede Dienstleistung standardisiert werden kann. Weiterhin kann eine zu starke Standardisierung die Kreativität von Mitarbeitern hemmen.

II.1.3.3.2 Gezielter Einsatz neuer Technologien

Durch den Einsatz neuer Technologien kann die Zeit für eine Prozessneugestaltung oder Prozessänderung verkürzt werden. Als Beispiel kann hier eine Neugestaltung der IT-Architektur in Form einer serviceorientierten Architektur (SOA) dienen. Durch die lose Kopplung von Services können neue Funktionen, ob intern oder extern, einfacher in ein bestehendes IT-System integriert werden. Ebenso erlaubt eine SOA durch standardisierte Schnittstellen die Änderung eines Services ohne die Funktionalität von anderen Services anzupassen. Eine weitere vielversprechende Technologie, die durch die Kombination aus Technologien des Semantic Web und des klassischen Prozessmanagements eine erhöhte Automatisierung in allen Phasen des Geschäftsprozessmanagement-Lebenszyklus erlaubt, ist

das Semantic Business Process Management (Hepp et al. 2005). Durch maschinenlesbare Informationen über Prozessschritte können Prozessmodelle automatisiert erzeugt werden, (Web-) Services können automatisiert einzelnen Geschäftsprozessschritten zugeordnet werden und Informationen können aus laufenden Geschäftsprozessen automatisiert ausgewertet werden. Während diese Technologien darauf abzielen, mittel- bis langfristig laufende Kosten zu senken, ist eine Vorteilhaftigkeitsbewertung der notwendigen Investitionen und die Einbeziehung weiterer, qualitativer, Kriterien, unabdingbar.

II.1.3.4 Änderungen bei eingebundenen Partnern

Die Fähigkeit, Flexibilität nicht nur im eigenen Unternehmen, sondern auch über die gesamte Wertschöpfungskette sicherzustellen, stellt eine enorme Herausforderung für Unternehmen dar. Daher müssen alle Flexibilitätsanforderungen, die ein Unternehmen an sich selbst stellt, an die angebundenen Unternehmen weitergegeben werden (Kumar et al. 2006). Um den damit verbundenen Auswahlvorgang zu unterstützen, sollten Entscheidungsträger analysieren, welche der bereits diskutierten Maßnahmen die angebundenen Unternehmen bereits in welchem Grad umgesetzt haben. Auf eine erneute Auflistung der Maßnahmen wird daher verzichtet. Eine Ausnahme stellt dabei die Strategie des Multi-Sourcing dar. Diese bezieht sich explizit auf die Anzahl der angebundenen Unternehmen und beleuchtet speziell im Dienstleistungsbereich technologische Entwicklungen und sich daraus ergebende Möglichkeiten.

II.1.3.4.1 Multiple Sourcing

Die Anbindung von mehreren Anbietern für eine Dienstleistung oder einen Dienstleistungsbestandteil kann ein Unternehmen gegen Lieferengpässe oder Ausfälle einzelner Anbieter absichern. Während diese Strategie im produzierenden Gewerbe bereits gängig ist, ist sie im Dienstleistungssektor nicht im selben Ausmaß verbreitet (Buhl et al. 2011). Gründe hierfür liegen neben Datenschutzbedenken in der Erwartung hoher Kosten der technischen Integration der Zulieferer. Diese negativen Erwartungen basieren jedoch meist auf veralteten Vorstellungen der Anbindung. So können mithilfe neuer Technologien wie einer SOA (siehe auch 3.3 Gezielter Einsatz neuer Technologien) einzelne Services leichter aus einem Prozess herausgelöst oder zu einem bestehenden Prozess hinzugefügt werden. Durch standardisierte Schnittstellen können damit die Kosten einer Anbindung gesenkt und mehrere Anbieter angebunden werden. Diesen Vorteilen stehen jedoch auch Risiken gegenüber: so

erhöht eine Sourcing Entscheidung an externe Partner die Abhängigkeit zu diesen, die kurzfristig oft nicht aufgelöst werden kann. Weiterhin ist genau zu beachten, welche zusätzlichen Transaktionskosten auftreten können und welche Prozesse geeignet sind, um diese einem externen Partner zu überlassen.

II.1.4 Erfahrungen und Lessons Learned aus der Praxis

Im Folgenden werden die bislang vorgestellten Maßnahmen episodisch anhand von konkreten Fällen aus der Praxis veranschaulicht. Dafür wurden Interviews mit einem Versicherungskonzern und einem Unternehmen aus der Telekommunikationsbranche geführt. Die Unternehmen sind weltweit agierend und beschäftigen jeweils 150.000 Mitarbeiter oder mehr. Beide Unternehmen gaben an, dass ein umfassender Bedarf an Flexibilität besteht und dass Projekte zur Steigerung der Prozessflexibilität eine dementsprechend hohe Priorität genießen. Aufgrund der Gesprächspartner der Interviews liegt der Fokus der Erfahrungen auf international agierenden Großkonzernen.

II.1.4.1 Sprachdialogsysteme

Bedarfstreiber: Schwankende Nachfragemenge nach bestehenden Dienstleistungen

Um die individuelle und persönliche Kundenbetreuung für eingehende Anfragen im Call Center des Telekommunikationsanbieters zu erhöhen, entschied sich das Unternehmen, das Sprachdialogsystem (IVR, Interactive Voice Response), mit welchem der Kunde das nachfolgende Routing seiner Anfrage bestimmt, vollständig auszuschalten. Stattdessen wurde die Anfrage direkt von einem Kundenberater entgegengenommen, nach Möglichkeit direkt bearbeitet oder zu anderen Experten weitergeleitet. Während die persönliche Betreuung von den Kunden sehr gut bewertet wurde, wirkte sie stark negativ auf die Flexibilität hinsichtlich schwankender Nachfragemengen, da das Unternehmen sowohl den **Automatisierungsgrad** als auch die **Kundeneinbindung in den Prozessablauf** reduzierte. Der damit einhergehende Flexibilitätsverlust führte in Lastzeiten zu einem starken Anstieg der Wartezeiten und erforderte zusätzliches Personal, um alle Kunden persönlich bedienen zu können. Als Resultat stellte das Unternehmen die Umstellung nach ca. einem Jahr aus Kostengründen ein und reaktivierte das Sprachdialogsystem.

II.1.4.2 Prozessabläufe im Callcenter

Bedarfstreiber: Änderungen in der Leistungserbringung bestehender Dienstleistungen

Im Call Center eines Telekommunikationsanbieters werden eingehende Anfragen je nach angefragter Dienstleistung intelligent an entsprechend ausgebildete Mitarbeiter geroutet. Der Ablauf des Gesprächs ist dabei auf hohe Durchsätze ausgelegt. Hierzu ist es nötig, die Ausführung der Prozessinstanzen so stark einzuschränken, dass hier kaum Flexibilität gegeben ist. Oftmals existieren Gesprächsleitfäden für Mitarbeiter, die den genauen Ablauf des Gesprächs vorgeben und keine Abweichung in Reihenfolge oder gar eine direkte Änderung des Prozessmodells bzw. eine Abweichung davon zulassen. Eine Ausnahme stellen hochqualifizierte Betreuer von Premium-Kunden dar. Diesen werden weitergehende Kompetenzen und Gestaltungsmöglichkeiten zugestanden, um eine möglichst hohe Kundenzufriedenheit pro Anfrage anstatt eines hohen Durchsatzes an Anfragen zu erreichen. Die Flexibilität im Prozessablauf wird für jegliche Kundengruppe weiterhin durch die vorgestellte Maßnahme „**Umfangreiche Alternativen in der Prozessdefinition**“ erhöht, so dass in einer Knowledge-Base eine Vielzahl an möglichen Prozessabläufen vorgegeben werden und somit meist schon vor dem Auftreten der Anfrage klar ist, wie dieser zu bearbeiten ist.

II.1.4.3 Releasezyklus-Management

Bedarfstreiber: Neue oder veränderte Dienstleistungen

In der Telekommunikationsbranche besteht das Angebot zu großen Teilen aus IT-Dienstleistungen, die dem Kunden zur Verfügung gestellt werden. Aus diesem Grund sieht sich der betrachtete Telekommunikationsanbieter mit einer hohen vierstelligen Anzahl an Anforderungen konfrontiert, die bestehende IT-Systeme verändern oder neue Dienstleistungen durch geeignete IT-Systeme erst ermöglichen. Diese Änderungen wurden bislang mit sechs Releasezyklen pro Jahr durchgeführt, wodurch sich eine durchschnittliche Umsetzungszeit pro Anforderung von ca. einem Jahr ergab. Um flexibler auf technologische Entwicklungen und Kundenwünsche einzugehen, wurde die bisherige Anzahl an Releasezyklen auf acht erweitert,

wobei im Wechsel ein Hauptrelease und ein Nebenrelease ausgerollt werden. Durch diese Maßnahme konnten insbesondere kleinere Änderungen schneller umgesetzt werden, da diese nicht auf andere, umfangreichere Releases warten müssen. Gleichzeitig konzentriert sich ein Hauptrelease auf wenige große Anforderungen. Durch diese Umstellung konnte die durchschnittliche Umsetzungszeit einer Anforderung von einem Jahr auf sechs Monate reduziert werden.

II.1.4.4 Mobile Schadenserfassung

Bedarfstreiber: Schwankende Nachfragemenge nach bestehenden Dienstleistungen

Um die Durchlaufzeit von KFZ-Schadensmeldungen zu senken, entwickelt die betrachtete Versicherung derzeit einen neuen Prozess, der vom Kunden selbst via Smartphone App ausgeführt werden kann. Im Schadenfall startet der Kunde die App, beantwortet zehn Fragen zum Schadenshergang und schickt seine Antworten mitsamt eines Schadensfotos an das Versicherungsunternehmen. Das Unternehmen verarbeitet die Antworten automatisiert und leitet ebenfalls automatisiert weitere Schritte wie die Veränderung der Versicherungsstufe des Kunden sowie eine entsprechende Schadensauszahlung ein. Somit handelt es sich bei der vorgestellten Maßnahme um eine Kombination aus **hoher Automatisierung** und **Einbindung des Kunden in den Prozessablauf**. Um Missbrauch zu vermindern, werden automatisiert verschiedene Kriterien, wie die Anzahl und Frequenz der letzten Schadensmeldungen und die Höhe des Schadens überprüft. Je nach Ergebnis dieser Prüfung werden manuelle Prozessschritte mit eingebaut. So kann ein Spezialist das mitgelieferte Foto des Schadens detaillierter prüfen oder ein Gutachter eingeschaltet werden.

II.1.4.5 Multi-Skilling

Bedarfstreiber: Schwankende Nachfragemenge nach bestehenden Dienstleistungen

Sowohl bei dem untersuchten Telekommunikationsunternehmen als auch bei dem Versicherungsdienstleister spielt im Telefonsupport **Multi-Skilling** eine große Rolle.

Mitarbeiter können dabei unterschiedliche Skills erlernen, die sie für die Bearbeitung unterschiedlicher Anfragen befähigen. Dabei stellt das Multi-Skilling von Mitarbeitern einen nicht zu vernachlässigenden Kostenblock dar, da auf diese Weise befähigte Mitarbeiter weit besser bezahlt werden und die Ausbildung sowie die Sicherstellung des aktuellen Wissens ebenfalls Kostentreiber darstellen. Daher hat sich bei beiden Unternehmen die Praxis durchgesetzt, nur einen Teil der Mitarbeiter pro Team (ca. 20 %) mithilfe von Trainingsmaßnahmen zu sogenannten Springern auszubilden. Die Anzahl der unterschiedlichen Skill-Gruppen ist dabei essentiell. Zu wenige Skill-Gruppen (ca. <8) bedeutet bei großen Dienstleistern mit hohem Leistungsumfang meist zu generische Skills, während eine zu hohe Anzahl (ca. > 30) zu hohe Trainingskosten verursacht.

II.1.4.6 Modularisierung und Standardisierung im Versicherungsbereich

Bedarfstreiber: Neue oder veränderte Dienstleistungen

In Deutschland müssen unterschiedliche Versicherungsarten (z.B. Lebensversicherung und Sachversicherung) von rechtlich getrennten Gesellschaften angeboten werden. Dies führt üblicherweise dazu, dass eine Dachgesellschaft verschiedene Tochtergesellschaften für unterschiedliche Versicherungsarten betreibt. Ein Kunde sollte diese Trennung nicht aktiv wahrnehmen, da er gefühlt nur den Kontakt zur Dachgesellschaft hat. Treten nun Änderungen ein, die alle Produkte (**Module**) des Kunden über alle Tochtergesellschaften hinweg betreffen, ist es für ein Unternehmen eine Herausforderung, diese Veränderungen flexibel umzusetzen. Im vorliegenden Fall betrifft die Umstellung auf das SEPA-Verfahren alle Verträge des Kunden, da in jedem Vertrag die Kontoverbindung angepasst werden muss. Die Schwierigkeit bestand für das betrachtete Unternehmen darin, dass der Kunde nicht für jeden Vertrag seine Kontoverbindung ändern soll, sondern einmal für alle vorliegenden Verträge. Um diese und ähnliche Änderungen in Zukunft durchführen zu können, führt das betrachtete Unternehmen derzeit ein **standardisiertes** Onlineportal ein, das alle Verträge des Kunden umfasst und die Stammdaten zentral und veränderbar vorhält. Um dies zu ermöglichen, wurde eine einheitliche Kundennummer für alle Kunden eingeführt, da die Tochtergesellschaften bislang eigene Kundennummern vergeben haben. Um die Verträge der einheitlichen Kundennummer zuordnen zu können, laufen einerseits diverse Matching-Algorithmen ab, die auf Namen,

Adressen und anderen Stammdaten des Kunden basieren. Um eine korrekte Zuordnung sicherzustellen und Dubletten zu vermeiden, fragt das Unternehmen zusätzlich die Vertragsnummern des Kunden beim erstmaligen Login in das Onlineportal ab. Durch die vorgestellte Maßnahme können Änderungen an Dienstleistungen standardisiert über alle Teilmodule hinweg durchgeführt werden.

II.2 Literatur

- Buhl, H.U., Dorsch, C., and Henneberger, M. 2011. „Multiple-Sourcing-Strategien bei Finanzdienstleistern – Eine Analyse zum Einfluss der Integrationskosten am Beispiel der Wertpapierabwicklung“ in *Die Unternehmung* (65:4), pp. 334-351.
- Easton, F.F. 2011. „Cross-Training Performance in Flexible Labor Scheduling Environments,” in *IIE Transaction* (43:8), pp. 589-603.
- Fitzsimmons, J.A., and Fitzsimmons, M. J. 2010. *Service Management: Operations, Strategy, Information Technology*. New York, USA, Mcgraw-Hill.
- Hepp, M., Leymann F., Domingue J., Wahler A., and Fensel D. 2005. „Semantic Business Process Management: A Vision towards Using Semantic Web Services for Business Process Management,” *Proceedings of the IEEE International Conference on e-Business Engineering*, October 2005, Beijing, China, pp. 535-540.
- Jordan, W.C., Graves, S.C. 1995. „Principles on the Benefits of Manufacturing Process Flexibility,” in *Management Science* (41:4), pp. 577-594.
- Kaganer, E., Carmel, E., Hirschheim, R., and Olsen, T. 2013 „Managing the Human Cloud,” *MIT Sloan Management Review* (54:2), pp. 23-32.
- Kumar, V.; Fantazy, K. A.; Kumar, U.; Boyle, T. A. 2006. „Implementation and Management Framework for Supply Chain Flexibility,” in *Journal of Enterprise Information Management* (19:3), pp.303-319.
- Leimeister, J. M. 2012, *Dienstleistungsengineering und-management*, Heidelberg, Germany, Springer.
- Luftman, J.; Zadeh, H. S.; Derksen, B.; Santana, M.; Rigoni, E. H.; Huang, Z. 2012. „Key Information Technology and Management Issues 2011-2012: an International Study,” in *Journal of Information Technology* (27:3), pp. 198-212.
- OECD. 1998. „The Challenge of Measuring and Evaluating Organisational Change in Enterprises,” Paris, France, OECD.
- Schonenberg, H., Mans, R. S., Russell, N. C., Mulyar, N. A., and van der Aalst, W. M. P. 2008. „Process Flexibility: A survey of Contemporary Approaches,” in *Advances in Enterprise Engineering*, Berlin, Germany, Springer, pp. 16-30.

Zapf, I. 2012. „Flexibilität am Arbeitsmarkt durch Überstunden und Arbeitszeitkonten: Messkonzepte, Datenquellen und Ergebnisse im Kontext der IAB-Arbeitszeitrechnung,“ IAB Forschungsbericht.

III Bewertung von Prozessflexibilität

Nachdem der Flexibilitätsbedarf und geeignete Maßnahmen zur Steigerung der Prozessflexibilität identifiziert wurden, ist eine fundierte ökonomische Bewertung der Maßnahmen für deren sinnhafte Auswahl unabdingbar (siehe auch Kapitel I und insbesondere Abb. I-3). In Kapitel III werden daher quantitative Modelle vorgestellt, die die ex-ante Bewertung von spezifischen Maßnahmen unter ökonomischen Aspekten ermöglichen. Die Beiträge adressieren dabei unterschiedliche Dimensionen der Prozessflexibilität und unterscheiden zwischen der Bewertung von Einzelprojekten und der ökonomisch fundierten Auswahl von mehreren Projekten zur Steigerung der Prozessflexibilität (siehe auch Abb. I-4). Beitrag 2 unterstützt dabei die Auswahl von Projekten, die entweder die inhaltliche Flexibilität oder die Volumenflexibilität von Prozessen steigern. Nachfolgend wird in Beitrag 3 ein Modell zur Bewertung von flexiblen Kapazitäten zur Steigerung der Volumenflexibilität vorgeschlagen. Eine weitere Maßnahme zur Steigerung der Volumenflexibilität von Prozessen wird in Beitrag 4 vorgestellt. Die Arbeit stellt ein auf Realoptionen basierendes Bewertungsmodell vor, mit dessen Hilfe die IT-basierte Einbindung eines externen Service-Anbieters aus einer ökonomischen Perspektive betrachtet werden kann. Die Analyse der inhaltlichen Dimension von Prozessflexibilität findet sich daran anschließend in Beitrag 5. Darin wird automatisiertes Prozess-Redesign als Alternative zum manuellen Prozess-Redesign vorgestellt und bewertet.

Anmerkung: Da die Beiträge 2-5 eng zusammenhängen und denselben Forschungsgegenstand aus unterschiedlichen Perspektiven betrachten, greifen die Beiträge häufig auf dieselbe Literatur zur Motivation und zur Erläuterung des theoretischen Hintergrunds zu. Um Redundanzen in den zugehörigen Literaturverzeichnissen zu vermeiden, wurden diese zusammengefasst und um Mehrfachnennungen bereinigt. Dieses übergreifende Literaturverzeichnis findet sich am Ende von Kapitel III anstatt separat bei jedem Beitrag.

III.1 Beitrag 2: „Flexibilization of Service Processes: Toward an Economic Optimization Model“

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Zusammenfassung

Although the importance of flexibility has long been recognized in the service industry, scholars and practitioners alike still struggle to express the value of flexible services in economic terms. We perceive that many service providers tend to strive for very flexible service processes no matter in which ecosystem they are embedded. They invest huge amounts of money in flexibilization projects without being able to justify their decisions in line with economic criteria. Scholars, in contrast, advise against investing as much as possible in flexibilization. Concrete recommendations, however, are missing. Especially insights into the positive economic effects of flexible service processes require more attention. Against this backdrop, we propose an economic optimization model as a first step to capture the general relationships that govern the flexibilization of service processes. The optimization model enables service providers to estimate appropriate levels of volume and functional flexibility and to select flexibilization projects accordingly. We also provide first insights into the applicability of the optimization model via a demonstration example.

III.1.1 Introduction

In all industrial nations, services are the biggest and most strongly growing business sector. In Germany, for instance, 74% of all workers were employed in the service sector and the service sector accounted for 71% of the gross domestic product in 2010 (OECD 2012). As today's business environment is characterized by increasing requests for individualized services and high demand uncertainty, flexibility becomes ever more important (Gong and Janssen 2010; Goyal and Netessine 2011). However, more flexibility is not necessarily better (He et al. 2012). Rather, flexibility has no value per se! Numerous service providers (SPs) nevertheless tend to strive for very flexible processes and invest huge amounts of money seemingly independent of their ecosystem. Justifying such investments in line with economic criteria is challenging for practitioners and scholars alike. Thus, an economic analysis of investments in the flexibilization of service processes is worthwhile.

Although business process flexibility in general is of high interest for scholars of various disciplines, there is only little research on its economic valuation. Only lately attention has been paid to quantitative approaches to valuating business process flexibility. The first approaches proposed by Gebauer and Schober (2006) and Schober and Gebauer (2011) use decision tree analysis and real options theory to determine how much to spend on the flexibility of information systems while considering the uncertainty, variability, and time-criticality of the business processes involved. They treat flexibility as cost reductions, but do not consider positive effects, e.g., increased volume of sales. Braunwarth et al. (2010) investigate a particular form of flexibility, i.e., the ability to set the degree of automation dynamically at run time based on the current workload. Braunwarth and Ullrich (2010) present another real options based model to value flexibility. In their paper, they focus on the integration of external SPs to deal with excess demand. They deal with service processes without direct customer contact, a property that holds true for a small fraction of service processes only. To sum up: Despite the importance of flexible business processes in general and service processes in particular, scholars and practitioners still struggle when valuating flexibility in an economic manner. What is missing is a valuation and decision framework that helps deal with different flexibilization projects (FPs) considering both positive and negative economic effects of flexible service processes. Therefore, we deal with the following research question: *How much should a SP invest in the flexibilization of its services process?*

As a first step to answer this question, we propose an economic optimization model to capture the general relationships that govern the flexibilization of service processes. Based on a cash flow analysis, the model enables SPs to estimate appropriate levels of flexibility and to select FPs accordingly. Thereby, we deliberately argue from a high level of abstraction and emphasize positive economic effects. We also focus on two distinct kinds of flexibility, namely volume flexibility and functional flexibility.

The remainder of this paper is structured as follows: In section 2, we sketch the theoretical background regarding the services domain and business process flexibility. Section 3 presents the economic optimization model. In section 4, we provide first insights into the applicability of the optimization model via a demonstration example. We conclude in section 5 with a brief summary, limitations, and an outlook.

III.1.2 Theoretical Background

III.1.2.1 Services, Service Processes, and the Impact of Time

Services are typically defined via constitutive criteria. The most fundamental criteria include immateriality, inseparability of production and consumption, and the integration of customers into the value creation process (Johnston et al. 2012). Thus, services are typically referred to as an intangible personal experience that cannot be stored or transferred (Fitzsimmons and Fitzsimmons 2010). As services cannot be physically stored, the customers' time has to serve as a buffer to cope with deviations of supply and demand. That is why time plays a crucial role in service delivery.

From a process perspective, value creation with services splits into three phases (Alter 2010): First, SPs create awareness for their services and customers become aware of their need. Second, both parties negotiate their commitments. Third, SPs and customers co-create the service. In this paper, we focus on the third phase and take on an SP's perspective. For an economic analysis of flexibility, we furthermore use a classification schema that classes service process instances into runners, repeaters, and strangers (Johnston et al. 2012). Runners denote standard activities found in high volume operations. Repeaters are also standard activities, but more complex and less frequent. Strangers are non-standard activities caused by (unplanned) extraordinary requests that are usually associated with a unique project or activity. While runners and repeaters can be performed immediately, strangers require additional set-up and preparation.

Services are typically reckoned time-sensitive. From a single customer's perspective, a service only generates value if it is delivered within a certain period of time. From an SP's perspective, the value of a service decreases with the time it takes to deliver the service. This is because customers usually have different preferences regarding time. In a competitive market, excessive waiting – or even the expectation of long waiting – may lead to lost sales (Fitzsimmons and Fitzsimmons 2010). That is, customers either leave before they are served or reconsider their need. From a customer perspective, only one period of time needs to be considered, which we call total service time. This period starts when the customer requests a service and ends when the service is delivered. From an SP perspective, however, total service time splits into three distinct parts, namely waiting time, set-up time, and processing time. Customers have to wait if demand exceeds capacity (Gross et al. 2008). Analogous to queuing theory, the SP has not yet started to handle the customer's request in this period of time. The set-up time is relevant for strangers only. It refers to the period where the SP has not yet started to execute the request, but is already preparing employees, devices, machines, processes, or systems (Cheng and Podolsky 1996). Finally, processing time relates to the period where the service is produced in collaboration with the customer (Curry and Feldman 2011). We get back to this classification schema when we present the economic model. We admit that the amount of customers willing to pay for a service may also depend on other criteria, e.g., the quality of the service or past experiences. Those criteria are mainly discussed in the marketing literature (e.g., Kumar et al. 2010; Montoya et al. 2010) and treated as constant here.

III.1.2.2 Flexibility of business processes

In order to determine its value, flexibility needs to be understood in more detail. In literature, flexibility is considered as an academically immature concept (Chanopas et al. 2006; Saleh 2009). Sethi and Sethi (1990), for example, compiled more than 50 definitions of different kinds of flexibility from the manufacturing context. Typically, flexibility refers to distinct objects (e.g., business processes, infrastructure, or information systems) or types (e.g. strategic, operational). In this paper, we define flexibility as “the capability of a system to react to or to anticipate system or environmental changes by adapting its structure and/or its behavior considering given objectives” (Wagner et al. 2011, p. 811).

We analyze the operational flexibility of service processes and focus on two particular kinds, namely volume flexibility and functional flexibility. Volume flexibility enables to cope with uncertain demand, particularly excess demand. Functional flexibility helps deal with increasing

service variety that is rooted in the demand for individualized treatment and becomes manifest in (unplanned) extraordinary requests, i.e., strangers. Note that functional flexibility does not improve the ability to handle a specific stranger. Rather, it yields better capabilities for coping with strangers in general. Volume and functional flexibility are also known from labor and service management research where they are referred to as numerical flexibility and new product flexibility respectively (Johnston et al. 2012; OECD 1998). As many other types of flexibility can be transformed into volume and functional flexibility, our focus is not too restrictive. Other ways of classifying flexibility can be found in Snowdon et al. (2007), Soffer (2005), or Kumar and Narasipuram (2006).

To become more flexible, SPs have to implement FPs. Projects that increase volume flexibility include adjustments of work force size for example by using part time employees or flexible employment contracts (Cappelli and Neumark 2004; Van Jaarsveld et al. 2009). Standardization, short-time outsourcing, capacity sharing, and increased customer participation are considered reasonable, too (Fitzsimmons and Fitzsimmons 2010). Braunwarth et al. (2010) propose an algorithm that allows for adjusting the degree of automation dynamically at runtime. Projects that foster functional flexibility include multi-skilling, wide-skilling, extensive training, and re-training (OECD 1998). Moreover, using information systems and advanced approaches to business process design, e.g., configurable reference process models, have to be considered as well (Iravani et al. 2005).

III.1.3 Optimization model

III.1.3.1 General Setting

We consider a single service process. To cope with uncertain demand and strangers, appropriate levels of volume flexibility $f_{\text{vol}} \in [0; 1]$ and functional flexibility $f_{\text{fun}} \in [0; 1]$ have to be determined. As flexibility results from FPs, f_{vol} and f_{fun} can also be interpreted as the share of pre-selected and pre-ordered volume and functional FPs that must be implemented to attain the desired levels of flexibility. In the status quo, no FPs are implemented. We assume:

(A1) There is a pre-defined and pre-ordered set of volume and functional FPs, each. All pre-selected FPs fit the service process at hand. Moreover, FPs are infinitely divisible.

In line with value-based business process management, we use an objective function based on cash flows to determine the optimal levels of volume and functional flexibility (Buhl et al. 2011). To keep the complexity of the model manageable and to preserve analytic solvability,

we analyze a single period of time only. Nevertheless, the general relationships that govern the flexibilization of service processes are still captured. The cash flow splits into cash inflows $I \in \mathbb{R}_0^+$ and cash outflows $O \in \mathbb{R}_0^+$. Both depend on volume and functional flexibility. Thus, we get the following objective function that should be maximized:

$$\text{MAX: } CF(f_{\text{vol}}, f_{\text{fun}}) = I(f_{\text{vol}}, f_{\text{fun}}) - O(f_{\text{vol}}, f_{\text{fun}}) \quad (1)$$

Below, we first analyze the cash inflows and outflows – with an emphasis on inflows as positive economic effects of service flexibilization, then concretize the objective function, and solve the optimization model.

III.1.3.2 Analysis of cash inflows

The basic idea for analyzing the cash inflows is as follows: (1) more flexibility shortens the total service time (i.e., the time between service request and delivery), (2) a shorter total service time increases the number of realized consumer requests, and (3) realized consumer requests directly translate into cash inflows. We analyze the cash inflows along this sequence in reversed order: We first present the cash inflow components we consider and how total service time impacts the amount of realized consumer requests. Second, we analyze how flexibility influences total service time.

III.1.3.2.1 The impact of total service time

The cash inflows of the service process result from realizing consumer requests. From a conceptual perspective, consumer requests split into three groups that sum up to the service's market potential (Abb. III-1a). The bottom-most group represents requests from consumers who are interested in the service and happy with the current total service time. The group in the middle includes requests whose realization depends on how much the total service time can be shortened by means of flexibilization. Such requests relate to consumers who are interested in the service, but unhappy with the current total service time. The top-most group encloses consumer requests that are never realized, i.e., even if the total service time became zero. Such requests stem from consumers who are not interested in the service because they are locked-in with competitors or desire service variants that the SP is not able or willing to offer. In the real world, the size and existence of these groups depends on the service process under investigation.

Henceforth, we consider the two bottom-most groups and refer to them as the highest amount of consumer requests the SP can realize, $x_{\max} \in \mathbb{R}^+$.

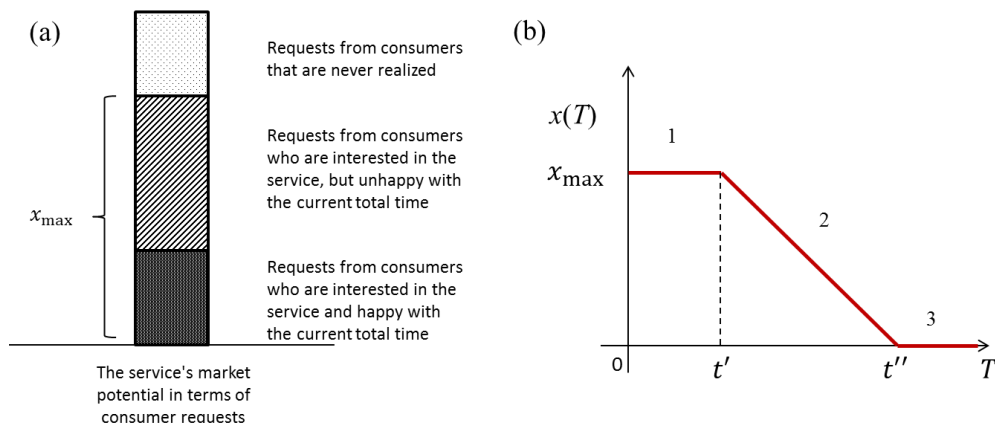


Abb. III-1

(a) Grouping of consumer requests

(b) Amount of realized consumer requests depending on the total service time

The amount of realized consumer requests depends on the total service time $T \in \mathbb{R}^+$, a relationship that we capture by means of the function $x(T) \in [0; x_{\max}]$. In line with the argumentation from above, the function $x(T)$ is piece-wise defined and monotonically decreasing (Abb. III-1b). The corresponding cash inflows are calculated by multiplying $x(T)$ with the profit contribution per request $p \in \mathbb{R}^+$. In part 1 of $x(T)$, the total service time falls short of a critical value (t') where all interested consumers are happy with the total service time. Therefore, the highest amount of consumer requests is realized and no additional requests can be realized. Reducing the total service time does not increase the cash inflows in this part. In part 3, the total service time exceeds a critical value (t'') where no consumers are willing to pay for the service anymore. Reducing the total service time by means of flexibilization is only reasonable if the total time can attain a value smaller than t'' . In part 2, the total service time takes a value between t' and t'' . Thus, a fraction of the highest amount of consumer requests is realized. This fraction decreases when the total service time increases. We assume:

(A2) The highest amount of consumer requests and the profit contribution are fixed and known. The amount of realized consumer requests only depends on the total service time. All consumer requests are treated as homogenous regarding their profit contribution. The consumers' preferences regarding total service time are uniformly distributed between t' and t'' .

Based on this assumption, we can model $x(T)$ as follows:

$$x(T) = \begin{cases} x_{\max} & \text{for } 0 \leq T \leq t' & \text{(part 1)} \\ \frac{x_{\max}}{t' - t''} \cdot (T - t'') & \text{for } t' < T < t'' & \text{(part 2)} \\ 0 & \text{for } t'' \leq T & \text{(part 3)} \end{cases} \quad (2)$$

III.1.3.2.2 The impact of flexibility

The total service time of a service process depends on how flexible the process is. Therefore, we examine which kind of flexibility drives which component of the total service time. The waiting time $T_{\text{wait}} \in \mathbb{R}^+$ does not only depend on the current workload, but also on how easily the SP is able to cope with demand fluctuations, particularly with the excess of expected demand. For this reason, waiting time is driven by volume flexibility. The set-up time $T_{\text{set-up}} \in \mathbb{R}^+$ indicates how easily the SP deals with strangers. It is thus influenced by functional flexibility. Moreover, set-up time is not influenced by volume flexibility and waiting time is not driven by functional flexibility. As neither volume nor functional flexibility influence the service itself, the processing time $T_{\text{proc}} \in \mathbb{R}^+$ is independent of any kind of flexibility we consider.

Below, we outline how volume and functional flexibility drive waiting time and set-up time. All time values we consider have to be interpreted as average values. In line with the argumentation so far, more functional flexibility implies less set-up time. That is, functional flexibility leads to monotonically increasing time savings $TS_{\text{set-up}}(f_{\text{fun}})$ compared to the actual set-up time $T_{\text{set-up,act}} \in \mathbb{R}^+$. In line with the theory of diminishing marginal utility, we treat the time savings as under-proportional (Mukherjee 2007). This is because implementing an additional FP has a higher relative impact on the set-up time if a small fraction of the pre-defined FPs has already been implemented compared to the case where almost all pre-defined FPs have been implemented. As we consider a SP that is currently not able to handle strangers within an appropriate set-up time, the high relative impact can be observed when the first FP is implemented. We use a power function that is strictly monotonically increasing and strictly concave to model the properties of the time savings related to set-up time.

$$T_{\text{set-up}}(f_{\text{fun}}) = T_{\text{set-up,act}} - f_{\text{fun}}^{\alpha} \cdot TS_{\text{set-up,max}} \quad (\text{with } TS_{\text{set-up,max}} \leq T_{\text{set-up,act}}) \quad (3)$$

The parameter $\alpha \in (0; 1)$ is responsible for the strictly concave course of the time savings. Its value has to be determined outside the optimization model. A key influencing factor of α is the variability of strangers. Therefore, α takes a value close to 0 if the service process faces a small number of distinct strangers with diverse frequencies. It takes a value close to 1 if many

different strangers need to be performed with about the same frequency. Gebauer and Schober (2006) rely on the same parameter for modeling the overall process variability. They operationalize it by means of the Lorenz curve concept.

Analogous to functional flexibility, volume flexibility shortens the waiting time of the service process, i.e., it leads to time savings $TS_{\text{wait}}(f_{\text{vol}})$ compared to the actual waiting time $T_{\text{wait,act}} \in \mathbb{R}^+$. These time savings have the same properties as the time savings that result from functional flexibility. Thus, we model the time savings resulting from volume flexibility analogous to formula (3).

$$T_{\text{wait}}(f_{\text{vol}}) = T_{\text{vol,wait}} - f_{\text{vol}}^{\beta} \cdot TS_{\text{wait,max}} \quad (\text{with } TS_{\text{wait,max}} \leq T_{\text{wait,act}}) \quad (4)$$

A key influencing factor of $\beta \in (0; 1)$ is the frequency of unexpected demand peaks of a service process. The parameter is considered to take small values if the SP needs to handle only a few unexpected demand peaks, while it is considered to be high when many unexpected demand peaks occur. Summing up, the total service time can be determined by adding up processing time, set-up time, and waiting time. It needs to be considered that the set-up time is zero for runners and repeaters. Therefore, we split the amount of consumer requests into a share of runners and repeaters and a share of strangers.

(A3) All values needed for calculating the time savings are fixed and known. The same holds true for the share of the service process instances that are runners and repeaters $\delta \in [0,1]$.

As SPs typically face much more runners and repeaters than strangers, the parameter δ most likely takes values close to 1. Considering (A3), we calculate the total service time as follows:

$$T(f_{\text{vol}}, f_{\text{fun}}) = T_{\text{proc}} + (1 - \delta) \cdot [T_{\text{set-up}}(f_{\text{fun}}) + T_{\text{wait}}(f_{\text{vol}})] + \delta \cdot T_{\text{wait}}(f_{\text{vol}}) \quad (5)$$

III.1.3.3 Analysis of cash outflows

Investments in service process flexibilization also imply cash outflows. Cash outflows result from (a) the implementation of FPs, (b) administration, communication, and project management activities during the implementation of FPs, (c) support and maintenance activities throughout service execution, and (d) handling consumer request. Only the categories (a) to (c) depend on volume and functional flexibility. Category (d) depends on the amount of realized consumer requests and is already included in the profit contribution we defined above. The higher the levels of volume and functional flexibility, the more cash outflows occur. Moreover, the cash outflows for administration, communication, and project management activities during

the implementation of FPs as well as the cash outflows for support and maintenance activities throughout service execution typically increase in an over-proportional manner (Verhoef 2002). We account for these characteristics using a strictly monotonically increasing and strictly convex function, which is quite similar to the functions we used for modeling the time savings.

$$O(f_{\text{vol}}, f_{\text{fun}}) = f_{\text{vol}}^{\varepsilon_1} \cdot c_{\text{vol},\text{max}} + f_{\text{fun}}^{\varepsilon_2} \cdot c_{\text{fun},\text{max}} \quad (6)$$

In this function, the cash outflow effects of volume and functional flexibility are modeled separately. Implementing all volume and functional FPs leads to the maximum cash outflows $c_{\text{vol},\text{max}}$ and $c_{\text{fun},\text{max}}$ respectively. Although a much more detailed analysis would have been possible, we look at cash outflows from a high level of abstraction because we put a special emphasis on the cash inflows as positive economic effects of service flexibilization. The parameters $\varepsilon_1 \in (1; \infty)$ and $\varepsilon_2 \in (1; \infty)$ are responsible for the cash outflow's strictly convex shape. Their values have to be determined outside the optimization model for example by relying on approaches to effort estimation. High values for ε_1 and ε_2 indicate that the service process has to deal with high project implementation and operational complexity respectively. Low values indicate the opposite. We assume:

(A4) All values needed for calculating the cash outflows are fixed and known.

III.1.3.4 Concretization of the objective function and determination of the optima

Based on the intermediate results, the objective function of the optimization model can be expressed more precisely. In line with value-based BPM, the SP strives to maximize the cash flow of the service process under investigation by increasing volume and functional flexibility. This leads to the following objective function:

$$CF(f_{\text{vol}}, f_{\text{fun}}) = \begin{cases} p \cdot x_{\text{max}} - (f_{\text{vol}}^{\varepsilon_1} \cdot c_{\text{vol},\text{max}} + f_{\text{fun}}^{\varepsilon_2} \cdot c_{\text{fun},\text{max}}) & \text{for } 0 \leq T(f_{\text{vol}}, f_{\text{fun}}) \leq t' \\ & \text{(part 1)} \\ p \cdot \left[\frac{x_{\text{max}}}{t' - t''} \cdot (T_{\text{proc}} + (1 - \delta) \cdot [T_{\text{set-up}}(f_{\text{fun}}) + T_{\text{wait}}(f_{\text{vol}})] + \delta \cdot [T_{\text{wait}}(f_{\text{vol}}) - t'']) \right] - (f_{\text{vol}}^{\varepsilon_1} \cdot c_{\text{vol},\text{max}} + f_{\text{fun}}^{\varepsilon_2} \cdot c_{\text{fun},\text{max}}) & \text{for } t' < T(f_{\text{vol}}, f_{\text{fun}}) < t'' \\ & \text{(part 2)} \\ -(f_{\text{vol}}^{\varepsilon_1} \cdot c_{\text{vol},\text{max}} + f_{\text{fun}}^{\varepsilon_2} \cdot c_{\text{fun},\text{max}}) & \text{for } t'' \leq T(f_{\text{vol}}, f_{\text{fun}}) \\ & \text{(part 3)} \end{cases} \quad (7)$$

The objective function is piecewise-defined because it inherits the parts and junction points of the function $x(T)$ (see formula 2 and Abb. III-1b). We therefore label the parts of the objective function analogous to the parts of $x(T)$. Accordingly, part 1 includes all cases where the total service time takes values between zero and the critical value t' where all interested consumers are happy with the total service time, i.e., $0 \leq T(f_{\text{vol}}, f_{\text{fun}}) \leq t'$. All these cases yield the highest amount of consumer requests and thus the highest cash inflows possible. The corresponding cash outflows, however, depend on the levels of volume and functional flexibility. Part 3 encompasses all cases where the total service time takes values beyond the critical value t'' where no consumers are willing to pay for the service anymore, i.e., $t'' \leq T(f_{\text{vol}}, f_{\text{fun}})$. Hence, no consumer requests and cash inflows are realized. Just like in part 1, the cash outflows depend on the levels of volume and functional flexibility. Finally, part 2 encloses all cases where the total service time takes values between t' and t'' , i.e., $t' < T(f_{\text{vol}}, f_{\text{fun}}) < t''$. Here, the cash inflows and the outflows depend on the levels of volume and functional flexibility.

The optimal levels of volume and functional flexibility can be determined by analyzing and optimizing the objective function step-by-step. We therefore revert to the three parts of the objective function as well as to two particular values of the total service time. These values are the total service time that is realized in case of no flexibilization, i.e., $T(0,0)$, and the total service time that is realized if the entire flexibilization potential is tapped, i.e., $T(1,1)$. We refer to these values as the maximum and minimum total service time respectively. Depending on the maximum and the minimum total service time, the objective function may include one, two, or all three parts outlined above. The reason is that the maximum and the minimum total service time may take values below t' , beyond t'' , or somewhere in between.

For each part of the objective function, a part-specific optimum can be determined. We refer to these optima as $CF_1^*(f_{\text{vol},1}^*, f_{\text{fun},1}^*)$ for part 1, $CF_2^*(f_{\text{vol},2}^*, f_{\text{fun},2}^*)$ for part 2, and $CF_3^*(f_{\text{vol},3}^*, f_{\text{fun},3}^*)$ for part 3. In part 3, more flexibility only increases the cash outflows. Thus, the objective function reaches its optimum if no flexibilization projects are implemented. That is, $f_{\text{vol},3}^* = 0$ and $f_{\text{fun},3}^* = 0$. Part 1 is similar to part 3. More flexibility only increases the cash outflows, while no cash inflows are realized. Therefore, the part-specific optimum results from those levels of volume and functional flexibility where the total service time equals t' , i.e., $T(f_{\text{vol},1}^*, f_{\text{fun},1}^*) = t'$. Part 2 is a bit more complex. When the total service time falls short of the value where no consumers are willing to pay for the service (t''), cash inflows and cash outflows

are increasing. Thus, the part-specific optimum depends on the parameters of the objective function. We therefore build the partial derivations of the objective function and use them to determine the optimal values of $f_{vol,2}^*$ and $f_{fun,2}^*$ ¹.

$$f_{vol,2}^* = \left(\frac{(t''-t') \cdot c_{vol,max} \cdot \varepsilon_1}{p \cdot x_{max} \cdot \beta \cdot TS_{wait,max}} \right)^{\frac{1}{\beta-\varepsilon_1}} \quad (8)$$

$$f_{fun,2}^* = \left(\frac{(t''-t') \cdot c_{fun,max} \cdot \varepsilon_2}{p \cdot x_{max} \cdot \alpha \cdot TS_{prep,max} \cdot (1-\delta)} \right)^{\frac{1}{\alpha-\varepsilon_2}} \quad (9)$$

As can be seen from formulae (8) and (9), the optimum of part 2 can be expressed analytically. With the objective function being strictly concave in part 2, the optimum is a maximum. Note that the optimum is only defined for combinations of $f_{vol,2}^*$ and $f_{fun,2}^*$ that yield a total service time between t' and t'' , i.e., $t' < T(f_{vol,2}^*, f_{fun,2}^*) < t''$. It might happen that the formulae return values above or below these borders. In the first case, the optimum is located at junction point of part 1 and 2, i.e., where $T(f_{vol,2}^*, f_{fun,2}^*) = t'$. In the second case, the optimum is located at junction point of part 2 and 3, i.e., where $T(f_{vol,2}^*, f_{fun,2}^*) = t''$. The overall optimum results from comparing the part-specific optima as shown in formula (10).

$$CF(f_{vol}^*, f_{fun}^*) = \max[CF_1^*(f_{vol,1}^*, f_{fun,1}^*), CF_2^*(f_{vol,2}^*, f_{fun,2}^*), CF_3^*(f_{vol,3}^*, f_{fun,3}^*)] \quad (10)$$

Summing up, the overall optimum of the objective function can be determined as follows: First, one has to determine which parts of the objective function have to be considered. This is done by determining the maximum and minimum total time of the service process. Second, the relevant part-specific optima need to be compared and the highest value has to be chosen.

III.1.4 Demonstration example

Although the paper was intended to capture the general relationships of service process flexibilization and to derive economically well-founded recommendations on a high level of abstraction, we would also like to provide some guidance on how to apply the optimization model in reality. Thus, we present a demonstration example that illustrates the basic steps of application. As the parameters of the optimization model may be estimated differently and as estimation always leaves space for subjective influences, we suggest not to decide on service process flexibilization exclusively based on the recommendations of the optimization model,

¹ An appendix with a detailed mathematical derivation of formulae (8) and (9) can be requested from the authors.

but to triangulate its recommendations with other sources of information before. Indeed, the usefulness of the recommendations depends on how reliably the parameters can be estimated.

In line with the general setting introduced above, the example is about a SP that strives to make one of its processes more flexible by implementing volume and functional FPs. As a foundation, the SP has already selected and ordered functional and volume FPs that fit the service process under investigation (Tab. III-1). The SP applies the optimization model to estimate the optimal levels of volume and functional flexibility in terms of cash flow and to determine the combination of FPs it should implement. Although the shares were modeled as continuous variables in the optimization model to allow for a general analysis, they take discrete values in reality. If one considers that volume and functional flexibility are independent, that the FPs related to each kind of flexibility build upon one another, and that the SP may also implement zero FPs, there are 25 feasible combinations of FPs.

Tab. III-1 Pre-selected and pre-ordered lists of volume and functional flexibilization projects

Volume FP		Stand-alone impact on f_{vol}	f_{vol}	Functional FP		Stand-alone impact on f_{fun}	f_{fun}
1	Introduction of flexible employment contracts	+ 0.4	0.4	1	Introduction of a reference process model	+ 0.1	0.1
2	Introduction of a part time employee system	+ 0.1	0.5	2	Multi-skilling of employees	+ 0.3	0.4
3	Outsourcing of selected process activities	+ 0.2	0.7	3	Expert training of employees	+ 0.2	0.6
4	Dynamic optimization of the degree of automatization	+ 0.3	1.0	4	Extension of information system support (e.g., using a knowledge management system)	+ 0.4	1.0

Before determining the optimal combination of FPs, we analyze the SP's business environment and internal conditions. In our example, the SP has to cope with a huge amount of strangers. Only 40% of the requests are runners or repeaters, while 60% are strangers. The set-up time can be reduced by 30 minutes from 40 to 10 minutes, while the waiting time can be reduced by 80 minutes from 120 to 40 minutes. Correspondingly, implementing all volume FPs is more expensive than realizing all functional FPs. Finally, the consumers of the service process are quite tolerant regarding the total service time, which is why the SP deals with a fairly diverse consumer portfolio. The first consumers are not interested in the service anymore or leave for competitors when the total service time takes a value of more than 70 minutes. Only beyond a value of 130 minutes, no consumers are willing to pay for the service. Therefore, a small deviation of the total service time does not lead to a huge difference of realized consumer requests. Finally, it is estimated that 150 consumer requests can be realized.

In reality, it is sometimes difficult to determine reliable values for some parameters. The processing time as well as the current set-up and waiting time can be determined in a straightforward manner, e.g., by analyzing the event logs of workflow management systems. The same holds true for the share of runners, repeaters, and strangers. The profit contribution can be extracted from enterprise resource planning systems or calculated using modeling tools with a process valuation component. The highest amount of consumer requests that can be realized can be estimated by the marketing department. The cash outflows that result from implementing all volume and functional FPs can be approximated by means of approaches from the effort estimation domain. Determining the maximum savings regarding set-up and waiting time, in contrast, relies much more on the experience of subject matter experts and BPM professionals. The parameters the most difficult to estimate are those that determine the shape of the time savings functions. For some of these parameters, operationalizations were proposed in the literature, e.g., the variability of strangers can be estimated using the Lorenz curve concept. We provided some further hints in the prior section. Summing up, we chose the following parameter values for our example:

- Cash inflows (see section 3.2): $t' = 70$ min, $t'' = 130$ min, $p = \$300$, $x_{\max} = 150$, $T_{\text{proc}} = 10$ min, $T_{\text{set-up,act}} = 40$ min, $T_{\text{wait,act}} = 120$ min, $TS_{\text{set-up,max}} = 30$ min, $TS_{\text{wait,max}} = 80$ min, $\delta = 0.4$, $\alpha = 0.5$, $\beta = 0.5$.
- Cash outflows (see section 3.3): $c_{\text{vol,max}} = \$30,000$, $c_{\text{fun,max}} = \$20,000$, $\varepsilon_1 = 1.4$, $\varepsilon_2 = 1.4$

To determine the optimum shares of volume and functional flexibility, we first analyze which parts of the objective function are included. We therefore determine the total service time when no volume and functional FPs are realized and the total service time when all volume and functional FPs are realized. The result is a maximum total service time of 154 minutes and a minimum total service time of 56 minutes. As the minimum total service time is smaller than t' and the maximum total service time is higher than t'' , we have to consider all three parts of the objective function.

According to formula (10), the overall optimum results from comparing the part-specific optima. As already mentioned above, the optimum of part 3 results from not investing into flexibilization at all. Hence, the part-specific optima are $f_{\text{vol},3}^* = 0$ and $f_{\text{fun},3}^* = 0$, which yields an optimum cash flow of $CF_3^* = 0$. In part 2, the optimum can be determined by means of

formula (8) and (9). This leads to $f_{vol,2}^* = 0.69$ and $f_{fun,2}^* = 0.21$ with an optimal cash flow of $CF_2^* = 17,931$. In part 1, reducing the total service time does not increase the cash inflows anymore while cash outflows are still increasing. Therefore, the optimum of part 1 results when the total service time equals the critical value (t') where all interested consumers are happy with the total service time. This leads to $f_{vol,1}^* = 0.87$ and $f_{fun,1}^* = 0.26$ with an optimal cash flow of $CF_1^* = \$17,092$. Since the optimal cash flow of part 2 exceeds the optimal cash flow of part 1 and part 3, the overall optimum equals the part-specific optimum of part 2. However, the exact values are not covered by the discrete values shown in Tab. 2. We therefore investigate each peripheral solution. The peripheral solutions regarding volume flexibility include the FPs 1-3 or the FPs 1-4. The peripheral solutions regarding functional flexibility include FP 1 or the FPs 1-2. Considering the results, we recommend implementing functional FP 1 together with volume FPs 1, 2 and 3. This leads to cash inflows of \$36,469 and cash outflows of \$19,004. Hence, the overall optimal cashflow is \$17,465.

Despite its brevity and limitations, the example demonstrated the basic steps that have to be conducted when applying the optimization model in the real world. We hope that it also advanced the understanding of the general relationships governing service process flexibilization.

III.1.5 Conclusion and Outlook

In this paper, we addressed the question of how much service providers should invest in the flexibilization of their service processes. We therefore presented an economic optimization model and corresponding analytic solutions that capture the general relationships of service process flexibilization with respect to volume and functional flexibility. The optimization model also enables to estimate which sub-set of pre-selected and pre-ordered flexibilization projects a service provider should implement. Paying particular attention to cash inflows and the constitutive criteria of services, we considered that flexibility as the key driver of the total time that consumers have to wait for service delivery, which in turn has an impact on whether consumers are willing to pay for the service.

We identified that, in general, it is not reasonable to invest as much in service flexibilization as possible. Rather, it can under certain conditions even be advisable not to invest in flexibilization at all. The optimal levels of flexibilization – and thus the set of flexibilization projects to be implemented – depend on parameters that relate to the service provider's business environment

and internal condition. These parameters include among other things the market potential of the service process, the time-sensitivity of the service provider's customer portfolio, the distribution of ordinary requests (i.e., runners and repeaters) and extraordinary requests (i.e., strangers) as well as the overall amount of extraordinary requests. It moreover needs to be considered how probable excess demand is and how well the company deals with the complexity of large flexibilization projects. These relationships do not depend on concrete parameter values.

As we investigated the problem of service process flexibilization from a high level of abstraction, the optimization model itself as well as its applicability are beset with limitations that should be subject to further research.

1. Currently, the appropriate levels of volume and functional flexibility are determined on the assumption of certainty. Since cash flows usually are stochastic in reality, the optimization model should be expanded by risk components to cope with uncertainties and dependency structures.
2. So far, the optimization model only considers a single period of investigation. While this enables capturing the relevant relationships of service process flexibilization, long-term effects are not integrated. In line with the previous limitation, the optimization model should be extended to a multi-period analysis, e.g., by relying on stochastic cash flow present values. This would also allow for analyzing the effects of investment outflows and recurring cash outflows separately.
3. We currently focus on a single service process as unit of analysis. Dependencies among multiple service processes are neglected. However, in order to maximize the cash flow of the SP, all service processes and their dependencies would need to be considered.
4. Finally, volume flexibility and functional flexibility are treated as independent as the corresponding flexibilization projects split into disjoint lists. It might be an interesting and promising avenue for future research to explore potential interaction effects between both kinds of flexibility in more detail.

Nevertheless, it needs to be deliberated for each extension whether the additional insights outweigh the additional complexity as well as the potential loss of analytic solvability and clarity. Despite its weaknesses, the optimization model advances the current knowledge regarding the economics of service process flexibilization by means of the uncovered general relationships and dependencies on internal and external parameters. We hope that this piece of

research provides fellow researchers with a sensible foundation for continuing research in the domain of service process flexibilization.

III.2 Beitrag 3: „The Business Value of Process Flexibility – An Optimization Model and its Application in the Service Sector“

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Zusammenfassung

Promising to cope with increasing demand variety and uncertainty, flexibility in general and process flexibility in particular become ever more desired corporate capabilities. During the last years, numerous approaches have been proposed from the business process management and the production/operations management communities that investigate how to value and determine an appropriate level of process flexibility. Most of these approaches are very restrictive regarding their application domain, neglect characteristics of the involved processes and outputs other than demand and capacity, and do not conduct a thorough economic analysis of process flexibility. Against this backdrop, we propose an optimization model that determines an appropriate level of process flexibility in line with the principles of value-based business process management. The model includes demand uncertainty, variability, criticality, and similarity as process characteristics. We also report on the insights gained from applying the optimization model to the coverage switching processes of an insurance broker pool company.

III.2.1 Introduction

In a world where many companies face strong competition, flexibility becomes an ever more desired corporate capability (van der Aalst 2013). In particular, flexible processes promise to cope with increasing demand variety and uncertainty (Goyal and Netessine 2011). More flexible processes, however, are not necessarily better (He et al. 2012). Rather, the appropriate level of process flexibility depends on the characteristics of the business environment and the involved processes as well as on the economic effects that go along with investing in process flexibility (Neuhuber et al. 2013; van Biesebroeck 2007).

Due to the importance of process flexibility, many researchers have already investigated how to value and determine an appropriate level of process flexibility. The related work splits into two streams. In the first stream, processes are interpreted as business processes, i.e., coordinated sets of tasks for achieving a particular result, as it is typical for the business process management (BPM) community (Dumas et al. 2013). In the second stream, processes are restricted to the manufacturing domain. With most approaches originating from the capacity-flexibility and the production/operations management literature, determining the optimal level of process flexibility is treated as a product-plant allocation problem.

As for the first stream, Braunwarth et al. (2010) help insurance companies determine at runtime whether claims should be handled automated or manually and flexible. Their optimization model relies on the expected present value of the short-time cash effects and the hard-to-measure long-term effects on customer satisfaction. Due to its focus on runtime decision support, the model neglects the investments required to establish process flexibility. Braunwarth and Ullrich (2010) propose a model that supports service providers in deciding whether cases should be executed in-house or routed to an external service provider depending on the workload. Neuhuber et al. (2013) determine the optimal level of volume and functional flexibility of a service process to prepare the selection of flexibility projects. Despite its focus on the positive economic effects of process flexibility, the model only accounts for a single period and deterministic cash flows. As for the second stream, Jordan and Graves (1995) investigate the benefits of process flexibility. They found that limited process flexibility leads to almost the same benefits as total flexibility in terms of capacity utilization and increased expected sales. Despite seminal results, their analysis is restricted to demand and capacity information, neglects negative effects of process flexibility, and abstracts from an economic evaluation. He et al. (2012) treat process flexibility as the ability to reallocate capacity between

process outputs. Extending Jordan and Graves (1995), their model includes the demand correlations between different outputs when identifying the need for process flexibility. However, they also neglect that flexibility requires investments, that the ability to reallocate capacity depends on the involved processes and outputs, and that reallocating capacity also has economic effects. Further, they treat process flexibility as a binary concept, i.e., a process is either flexible or not. Tanrisever et al. (2012) incorporate on-going costs and a multi-period planning horizon. Nevertheless, they still neglect relevant process characteristics and investments.

The preceding review leads to the following research gap: First, current optimization models that deal with process flexibility are either restricted to the manufacturing area or focus on processes from specific application domains. Characteristics of the involved processes and outputs other than capacity and demand that influence the appropriate level of process flexibility are barely considered. What is missing is a more general guidance that abstracts from the peculiarities of distinct application domains and goes beyond demand and capacity information. Second, most existing optimization models either neglect the economic effects of process flexibility or only consider how process flexibility reduces costs. Most approaches considering the positive economic effects of process flexibility do this in a coarse-grained and hard-to-measure way or neglect the stochastic and long-term nature of these effects. Therefore, a thorough economic analysis of process flexibility decisions is missing.

In this paper, we propose an optimization model that addresses both issues of the research gap. The model considers two processes, one with an inferior and the other with a superior output in terms of profit margin. In line with the existing literature (e.g., He et al. 2012), process flexibility refers to the fraction of capacity that may be reallocated from one process to another. To determine how flexible both processes should be, the model analyzes which fractions of flexible capacity maximize the risk-adjusted expected net present value (NPV), a quantity compliant with the principles of value-based BPM. Thus, the model accounts for positive and negative economic effects of process flexibility such as investment outflows, increased cash inflows from selling more superior outputs, and opportunity costs caused by reallocating capacity. Furthermore, the model is broadly applicable as it incorporates parameters whose values can be easily assessed. These parameters include a uniformly distributed demand for the process outputs and process characteristics like similarity, criticality, and variability. The focus on two processes and a uniformly distributed demand allows for systematically structuring the

optimization problem from an economic perspective, for incorporating the cash effects of relevant parameters, and for analytically deriving an optimal level of process flexibility. With this paper, we also contribute to the process improvement area where novel approaches – particularly those that take on an economic perspective and extend current decision-making capabilities – are in high demand (van der Aalst 2013; vom Brocke et al. 2011) We also extend our prior work by relaxing some assumptions, considering both processes as flexible, and providing a real-world example from the services sector (Afflerbach et al. 2013).

We proceed as follows: In section 2, we outline the theoretical background of process flexibility and value-based BPM. In sections 3 and 4, we present the optimization model and report on the insights gained from applying the model to the coverage switching processes of an insurance broker pool company. In section 5, we discuss limitations and point to topics for future research.

III.2.2 Theoretical background

2.1 Foundations of process flexibility

Flexibility is an immature concept whose vagueness resulted in an abundance of definitions (de Toni and Tochia 1998; Saleh et al. 2009; Sethi and Sethi 1990). There are both very generic definitions that do not allow for concrete measurement and highly specific definitions that focus on single facets of flexibility (Johnston and Clark 2005; Zelenovic 1982). In general, flexibility can be treated as the ability of a “system to react to or to anticipate system or environmental changes by adapting its structure and/or its behavior considering given objectives” (Wagner et al. 2011a, p. 811).

We define process flexibility using an adapted version of Goyal and Netessine’s (2011) definition of product flexibility, an analogy that is reasonable as processes also create value-added output (Dumas et al. 2013). Accordingly, process flexibility refers to the *ability to create multiple outputs on the same capacity and to reallocate capacity between processes in response to realized demand*. As defined here, process flexibility leads to volume flexibility that is achieved by making the involved processes functionally flexible using a flexibility-by-design strategy. Volume flexibility enables increasing and decreasing production above and below the installed capacity (Goyal and Netessine 2011). Functional flexibility enables delivering the desired output variety (Anupindi et al. 2012). Flexibility-by-design, as a particular strategy to implement functional flexibility, requires incorporating alternative execution paths in a process model at design time and selecting the most appropriate path at runtime (Schonenberg et al.

2008). Our definition of process flexibility fits the general definition from Wagner et al. (2011a) as it requires adapting the structure and behavior of the involved processes to enable reallocating capacity and coping with anticipated environmental uncertainty in terms of risky demand. The advantage of our definition is that the level of process flexibility can be easily measured. It also abstracts from concrete flexibility projects and applies to many processes as it only requires a high-level knowledge about the involved processes. Finally, our definition complies with other definitions of process flexibility such as those proposed by He et al. (2012), Iravani et al. (2005), or Jordan and Graves (1995).

When implementing process flexibility as defined here, it is worthwhile to look at how functional flexibility, particularly flexibility-by-design, is implemented. Functional flexibility has a rich tradition in BPM and workflow management as well as in capacity and workforce management (Kumar and Narasipuram 2006; Reichert and Weber 2012). From a process design perspective, flexibility-by-design can be implemented via configurable process models (Gottschalk et al. 2007). From a resource perspective, flexibility-by-design can be achieved via cross-training, multi-skilling, multi-purpose machines, IT-based assistance systems, and process-aware information systems (Iravani et al. 2005; Reichert and Weber 2012).

There are several characteristics that drive the need for process flexibility. Gebauer and Schober (2006) characterize a process via time-criticality, variability, and uncertainty. Time-criticality equals the fraction of time-critical tasks. Variability measures how frequently different process variants are performed. Uncertainty splits into environmental uncertainty (e.g., risky demand) and structural uncertainty (e.g., risks from within the process). He et al. (2012) also rely on uncertainty as a driver of process flexibility. Pujawan (2004) determines internal and external drivers of process flexibility, e.g., product variety and process similarity. Reichert and Weber (2012) present characteristics that determine the need for flexible processes supported by a process-aware information system, e.g., variability and looseness in the sense of uncertainty. Finally, Wagner et al. (2011b) present eight characteristics that drive the need for process flexibility, e.g., the cycle time of a process and the time between planning and execution. We incorporate uncertainty, variability, similarity, and criticality being the most popular drivers of process flexibility.

Another often-discussed issue is the relationship between process flexibility and standardization. Depending on the context, this relationship can be interpreted as conflicting or complementary. On the one hand, process flexibility and standardization can be treated as

conflicting as standardization may reduce the number of process variants and prohibit deviating from these variants, whereas more process variants and degrees of freedom during execution help cope with a higher desired output variety (Muenstermann et al. 2011; Pentland 2003). On the other hand, process flexibility and standardization can be seen as complementary, for instance if processes are defined in a way that enables assembling suitable processes at runtime and changing processes more easily (Schonenberg et al. 2008). In our multi-process context at hand, we treat process flexibility and standardization as complementary for two reasons. First, in line with the flexibility-by-design strategy, we require the variants, i.e. standardized execution paths, of each involved process to be known on a high level at design time. This can be reasonably assumed for standard and routine processes (Lillrank 2003). Second, we define a process as flexible if its capacity can be reallocated to create the output of other processes. Obviously, capacity can be reallocated more easily if other processes are more standardized, i.e., less variants have to be supported.

2.2 Value-based business process management

Value-based BPM is a paradigm where all process-related activities and decisions are valued according to their contribution to the company value (Buhl et al. 2011). Thereby, value-based BPM applies the principles from value-based management (VBM) to process decision-making. Building on the work of Rappaport (1986), Copeland et al. (1990) as well as Stewart and Stern (1991), VBM sets the maximizing of the long-term company value as the primary objective for all business activities. The company value is based on future cash flows (Rappaport 1986). In order to claim VBM to be implemented, companies must be able to quantify their value on the aggregate level as well as the value contribution of single activities and decisions. To comply with VBM, decisions must be based on cash flows, consider risks, and incorporate the time value of money (Buhl et al. 2011). There is a set of objective functions that can be used for value-based decision-making (Berger 2010). In case of certainty, decisions can be based on the NPV of the future cash flows. In case of risk with risk-neutral decision makers, decisions can be made based on the expected NPV. If decision makers are risk-averse, decision alternatives can be valued using the certainty equivalent method or a risk-adjusted interest rate. Intending to capture the effects of uncertainty, we use an expected NPV with a risk-adjusted interest rate.

III.2.3 Optimization model

III.2.3.1 General setting

We consider two processes operated by the same company. One process creates an inferior output, the other process a superior output. We refer to the process with the inferior output as inferior process, to the process with the superior output as superior process. Each process has a fixed capacity $C_{\text{sup/inf}} \in \mathbb{R}^+$. The demands $X_{\text{sup/inf}}$ for both outputs are assumed to be uniformly distributed in $[C_{\text{sup/inf}} - D_{\text{sup/inf}}^-, C_{\text{sup/inf}} + D_{\text{sup/inf}}^+]$, where $D_{\text{sup/inf}}^- \in \mathbb{R}_0^+$ and $D_{\text{sup/inf}}^+ \in \mathbb{R}^+$ denote the highest possible shortfall and excess demands relative to the capacities. The demand for both outputs is also assumed to be independent from each other. Finally, the periodic demands for each output are assumed to be independent and identically distributed.

Assumption 1: The demand for the inferior and the superior process output is uniformly distributed.

Although the normal distribution is a more standard way to model risky demand and has already been applied to process flexibility (He et al. 2012), we chose the uniform distribution. In fact, our model could not be solved analytically if a normally distributed demand were assumed because the required distribution function can only be approximated for a normally distributed demand. However, the uniform distribution can be fitted to the normal distribution in terms of expected value, standard deviation, and skewness. The normal distribution, however, has a larger kurtosis, i.e., demand realizations close to the expected value are more probable for a uniformly distributed demand. Thus, the model tends to underestimate the effect of process flexibility.

Assumption 2: The demand for the inferior output is independent from that for the superior output. The periodic demands for both process outputs are independent and identically distributed.

We assumed the demand to be independent across process outputs and time to reduce the complexity of our model and to be able to determine the optimal level of process flexibility for each process separately (Jordan and Graves 1995). If the demand for the process outputs depended positively (negatively), we would overestimate (underestimate) the effect of process flexibility. As companies are able to capture systematic dependencies in their capacity strategy (Zhang et al. 2003), the periodic noise can be reasonably treated as independent.

Enabling the reallocation of capacity, process flexibility is measured as the fraction of the capacity that can be used to produce the output of the other process. In this context, two decisions have to be made: an investment decision on the flexibility potential $F_{\text{sup/inf}} \in [0; 1]$ that is established for each process at the beginning of the planning horizon and an execution decision on the level of flexibility realized in each period $f_{\text{sup/inf}} \in [0; F_{\text{sup/inf}}]$. We use flexibility potential and flexibility as synonyms. This definition of process flexibility enables modeling the additional capacity of one process based on the flexibility and the capacity of the other process. To transform the provided capacity into additional capacity units, we use an exchange rate $T \in \mathbb{R}^+$. The exchange rate indicates how many units of the superior output can be produced by reallocating one capacity unit of the inferior process.

Process flexibility impacts cash inflows and outflows. As for the cash inflows, we need the profit margins of both process outputs $M_{\text{sup/inf}} \in \mathbb{R}^+$. Thereby, the profit margin of the superior output is higher than that of the inferior output ($M_{\text{sup}} > M_{\text{inf}}$). We assume the profit margins to be constant over time and the amount of outputs sold. This complies with cost-plus-pricing, an approach where companies add a fixed margin to the production costs to obtain the sales price (Arrow 1962; Guilding et al. 2005). As a result, additional sales volume directly translates into additional cash inflows. Likewise, capacity shortages translate into reduced cash inflows. Cash outflows, in contrast, result from implementing flexibility projects such as those sketched in the theoretical background.

Assumption 3: The profit margins are constant over time and over the sold amount of outputs.

In line with value-based BPM, we aim at maximizing the risk-adjusted expected NPV that goes along with investing in process flexibility. Our objective function equals the risk-adjusted expected NPV of the cash inflows $I \in \mathbb{R}_0^+$ and the cash outflows $C \in \mathbb{R}_0^+$.

$$\text{MAX: } I_{\text{sup}}(F_{\text{sup}}) + I_{\text{inf}}(F_{\text{inf}}) - C(F_{\text{sup}}) - C(F_{\text{inf}}) \quad (1)$$

Below, we substantiate the objective function by modeling its components in detail. We then solve the optimization model and present the optimal levels of process flexibility for both processes.

III.2.3.2 Cash inflow effects of process flexibility

The cash inflow effects of process flexibility result from different demand realizations. By determining whether and in which direction capacity should be reallocated, the cash inflow effects for different demand realizations can be analyzed. As for the inferior process whose capacity supports the superior process, expected inflow increases from selling more superior outputs and decreases from selling less inferior outputs have to be considered. As for the superior process whose capacity supports the inferior process, only expected inflow increases from selling more inferior outputs have to be considered. Reduced inflows from selling less superior outputs are not reasonable as the profit margin of the superior output is higher than that of the inferior product. As a foundation for calculating the expected inflow effects, we investigate the stochastic implied by different demand realizations based on the decision tree shown in Abb. III-2.

Case 1: If the demand for the superior output exceeds the capacity of the superior process, the superior process requires capacity from the inferior process. Due to the higher profit margin of the superior output, capacity of the inferior process is always reallocated if needed. If the capacity requirements are such high that the inferior process cannot serve its own demand anymore, the resulting capacity shortage causes decreased inflows from selling less inferior outputs. Thus, another case distinction is necessary that accounts for the demand realizations for the inferior output. If the demand for the inferior output exceeds the capacity of the inferior process (case 1.1), there will definitely be a capacity shortage. If the demand for the inferior output realizes below the capacity of the inferior process (case 1.2), the inferior process has free capacity. That is, there is a chance that the free capacity is sufficient to meet the capacity requirements of the superior process without causing a capacity shortage at the inferior process.

Case 2: If the demand for the superior output realizes below the capacity of the superior process, the superior process can serve its demand on its own. The flexibility of the inferior process is not used and does not cause additional inflows. Moreover, the superior process has free capacity that can be reallocated without negative effects. The inferior process only requires capacity from the superior process if the demand for the inferior output exceeds the capacity of the inferior process (case 2.1). In this case, the flexibility of the superior process causes additional inflows. If the demand for the inferior output realizes below the capacity of the inferior process (case 2.2), flexibility of the superior process has no inflow effects. Thus, this case is omitted from our analysis.

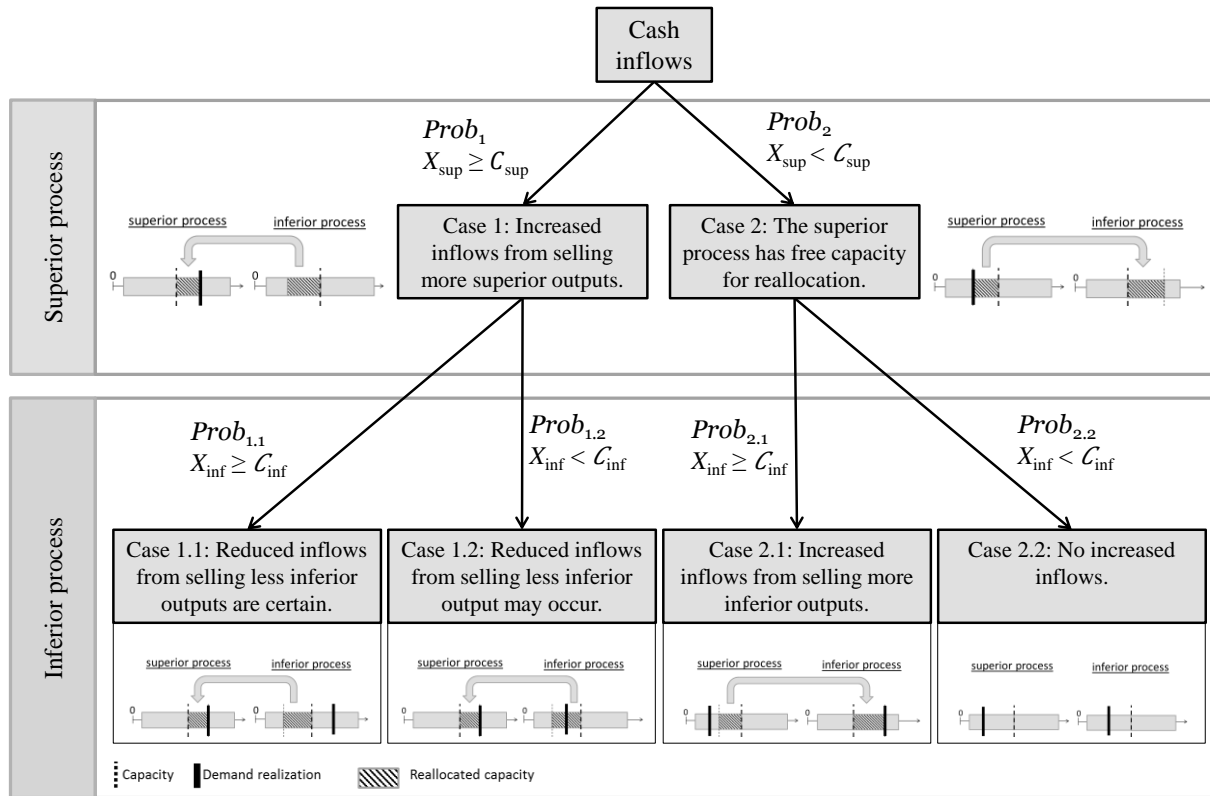


Abb. III-2 Decision tree for determining the cash inflows effects

Each case occurs with a distinct probability that can be derived from the properties of the uniform distribution as well as the maximum excess and shortfall demands relative to the capacities:

$$Prob_1(X_{sup} \geq C_{sup}) = \frac{D_{sup}^+}{D_{sup}^- + D_{sup}^+} \tag{2}$$

$$Prob_{1.1}(X_{sup} \geq C_{sup}; X_{inf} \geq C_{inf}) = \frac{D_{sup}^+}{D_{sup}^- + D_{sup}^+} \frac{D_{inf}^+}{D_{inf}^- + D_{inf}^+} \tag{3}$$

$$Prob_{1.2}(X_{sup} \geq C_{sup}; X_{inf} < C_{inf}) = \frac{D_{sup}^+}{D_{sup}^- + D_{sup}^+} \frac{D_{inf}^-}{D_{inf}^- + D_{inf}^+} \tag{4}$$

$$Prob_{2.1}(X_{sup} < C_{sup}; X_{inf} \geq C_{inf}) = \frac{D_{sup}^-}{D_{sup}^- + D_{sup}^+} \frac{D_{inf}^+}{D_{inf}^- + D_{inf}^+} \tag{5}$$

III.2.3.2.1 Cash inflow effects of the inferior process

III.2.3.2.1.1 Increased cash inflows from selling more superior outputs

In case of excess demand for the superior output (case 1), flexibility potential established in the inferior process creates additional inflows because capacity can be reallocated to increase the sales volume of the superior output. The realization of the excess demand thereby determines the realized flexibility. Due to the reproduction property of the uniform distribution, the excess demand is uniformly distributed in $[0, D_{\text{sup}}^+]$. To obtain the level of flexibility f_{inf} of the inferior process that has to be realized to cover a distinct excess demand for the superior output, the excess demand has to be divided by $C_{\text{inf}} \cdot T$. The realized level of flexibility then is a random variable uniformly distributed in $[0, \frac{D_{\text{sup}}^+}{C_{\text{inf}}T}]$. Its density function is $u(f_{\text{inf}}) = C_{\text{inf}}T/D_{\text{sup}}^+$ (Berger 2010).

For a given level of realized flexibility f_{inf} of the inferior process, the additional capacity for the superior process is obtained by multiplying the realized flexibility with the exchange rate and the capacity of the inferior process. As capacity is only reallocated if it is required to cover excess demand, additional capacity directly turns into additional sales volume. By multiplying the additional sales volume with the profit margin of the superior output, the profit function is $p(f_{\text{inf}}) = C_{\text{inf}}TM_{\text{sup}} \cdot f_{\text{inf}}$. One has to consider that not all excess demand realizations can be covered because the flexibility potential F_{inf} is an upper boundary for f_{inf} . Larger excess demands lead to a complete realization of the flexibility potential and to the corresponding cash inflows. Equation (6) shows the expected periodic inflow increases from selling more superior outputs. The first addend refers to the demand realizations that can be covered completely. The second addend deals with the demand realizations that cannot be covered completely.

$$\begin{aligned}
 E_1[p(f_{\text{inf}})] &= \int_0^{F_{\text{inf}}} C_{\text{inf}}TM_{\text{sup}}f_{\text{inf}} u(f_{\text{inf}})df_{\text{inf}} + \left(1 - \frac{C_{\text{inf}}T}{D_{\text{sup}}^+}F_{\text{inf}}\right) \cdot C_{\text{inf}}TM_{\text{sup}} \cdot F_{\text{inf}} \\
 &= M_{\text{sup}}C_{\text{inf}}T \cdot F_{\text{inf}} - \frac{M_{\text{sup}}C_{\text{inf}}^2T^2}{2D_{\text{sup}}^+} \cdot F_{\text{inf}}^2
 \end{aligned} \tag{6}$$

III.2.3.2.1.2 Reduced cash inflows from selling less inferior outputs

To derive the reduced inflows from selling less inferior outputs, we have to consider the demand distribution of both outputs. Reduced inflows result from the fact that less units of the inferior

output can be produced because the capacity of the inferior process is used (in parts) for creating the superior output. This corresponds to cases 1.1 and 1.2 from Abb. III-2.

In case 1.1, the demand for the inferior output exceeds the capacity of the inferior process. As the capacity of the inferior process is reduced at the same time, the remaining capacity is always smaller than the realized demand. This leads to a capacity shortage and reduced inflows. For a given level of realized flexibility f_{inf} , an amount of $f_{\text{inf}} \cdot C_{\text{inf}}$ capacity units has to be reallocated. The corresponding function for the reduced cash inflows is $o(f_{\text{inf}}) = C_{\text{inf}} M_{\text{inf}} \cdot f_{\text{inf}}$. To derive the expected inflow decreases, $o(f_{\text{inf}})$ has to be integrated over the density function $u(f_{\text{inf}})$. Analogous to the inflow increases, the highest possible inflow decreases depend on the flexibility potential F_{inf} of the inferior process. An illustration is shown in Abb. III-3a.

$$\begin{aligned} E_{1.1}[o(f_{\text{inf}})] &= \int_0^{F_{\text{inf}}} C_{\text{inf}} M_{\text{inf}} f_{\text{inf}} \cdot u(f_{\text{inf}}) df_{\text{inf}} + \left(1 - \frac{C_{\text{inf}} T}{D_{\text{sup}}^+} F_{\text{inf}}\right) \cdot C_{\text{inf}} M_{\text{inf}} \cdot F_{\text{inf}} \\ &= M_{\text{inf}} C_{\text{inf}} \cdot F_{\text{inf}} - \frac{M_{\text{inf}} C_{\text{inf}}^2 T}{2 D_{\text{sup}}^+} \cdot F_{\text{inf}}^2 \end{aligned} \quad (7)$$

In case 1.2, the inferior process has free capacity because the demand for the inferior output is smaller than the capacity of the inferior process. The free capacity $k_{\text{inf}} \in \mathbb{R}_0^+$ equals the difference between the realized demand and its capacity. As the free capacity can range from 0, if the demand for the inferior output equals the capacity of the inferior process, and D_{inf}^- , if the demand realizes at the minimum demand, it is uniformly distributed in $[0; D_{\text{inf}}^-]$ with a density function of $u(k_{\text{inf}}) = 1/D_{\text{inf}}^-$.

If the reallocated capacity $f_{\text{inf}} \cdot C_{\text{inf}}$ is smaller than the free capacity of the inferior process, there is no capacity shortage for the inferior output and no cash inflow decreases occur. If the reallocated capacity exceeds the free capacity, there is a capacity shortage that causes decreased inflows. Given a distinct free capacity, the lost sales volume of the inferior output equals the difference between the reallocated capacity and the free capacity ($f_{\text{inf}} \cdot C_{\text{inf}} - k_{\text{inf}}$). The expected loss in sales volume then equals the integral of this difference over the density function of the free capacity. As only realizations between 0 and $f_{\text{inf}} \cdot C_{\text{inf}}$ are relevant, the integral is parameterized accordingly. To obtain the expected inflow decreases for a distinct level of realized flexibility f_{inf} , the expected loss in sales volume has to be multiplied by the profit margin of the inferior output.

$$E_{1.2}[o(f_{\text{inf}})] = \int_0^{f_{\text{inf}} \cdot C_{\text{inf}}} (f_{\text{inf}} \cdot C_{\text{inf}} - k_{\text{inf}}) M_{\text{inf}} \cdot u(k_{\text{inf}}) dk_{\text{inf}} = \frac{C_{\text{inf}}^2 M_{\text{inf}}}{2 D_{\text{inf}}^-} \cdot f_{\text{inf}}^2 \quad (8)$$

To fully specify the inflow decreases, another technical case distinction is necessary. If the flexibility potential of the inferior process exceeds the threshold $D_{\text{inf}}^-/C_{\text{inf}}$ (case 1.2.1, Abb. III-3b), the realized flexibility f_{inf} of the inferior process can also exceed this threshold. The reallocated capacity $f_{\text{inf}} \cdot C_{\text{inf}}$ would be larger than the maximal free capacity D_{inf}^- of the inferior process and the capacity of the inferior process would be reduced below the minimum demand for the inferior output. Such a capacity reduction below the minimum demand leads to certain inflow decreases and has to be treated differently than capacity reductions where the remaining capacity is above the minimum demand, a constellation that causes uncertain inflow reductions only. If the flexibility potential is below the threshold $D_{\text{inf}}^-/C_{\text{inf}}$ (case 1.2.2, Abb. III-3c), the capacity of the inferior process cannot be reduced below the minimum demand. As a result, the inflow reductions are always uncertain. As the equations for the expected inflow reductions become very complex for this case distinction, we only show them in the appendix.

To get the inflow effects of making the inferior process more flexible for a single period, the results obtained so far must be combined by weighting them with their probability of occurrence. The periodic cash inflow function is continuous and monotonically increasing with decreasing marginal inflows.

$$I_{\text{inf}}^{\text{periodic}}(F_{\text{inf}}) = Prob_{1.1} \cdot E_1[p(f_{\text{inf}})] - Prob_{1.1} \cdot E_{1.1}[o(f_{\text{inf}})] \\ + Prob_{1.2} \cdot M_{\text{inf}} \cdot \left[\begin{array}{l} \left(-\frac{C_{\text{inf}}^2}{2D_{\text{inf}}^-} \cdot F_{\text{inf}}^2 + \frac{C_{\text{inf}}^3 T}{3D_{\text{inf}}^- D_{\text{sup}}^+} \cdot F_{\text{inf}}^3 \right) \text{ for } F_{\text{inf}} \leq \frac{D_{\text{inf}}^-}{C_{\text{inf}}} \\ \left(\frac{D_{\text{inf}}^-}{2} - \frac{(D_{\text{inf}}^-)^2}{6D_{\text{sup}}^+} - C_{\text{inf}} \cdot F_{\text{inf}} + \frac{C_{\text{inf}}^2 T}{2D_{\text{sup}}^+} \cdot F_{\text{inf}}^2 \right) \text{ for } F_{\text{inf}} > \frac{D_{\text{inf}}^-}{C_{\text{inf}}} \end{array} \right] \quad (9)$$

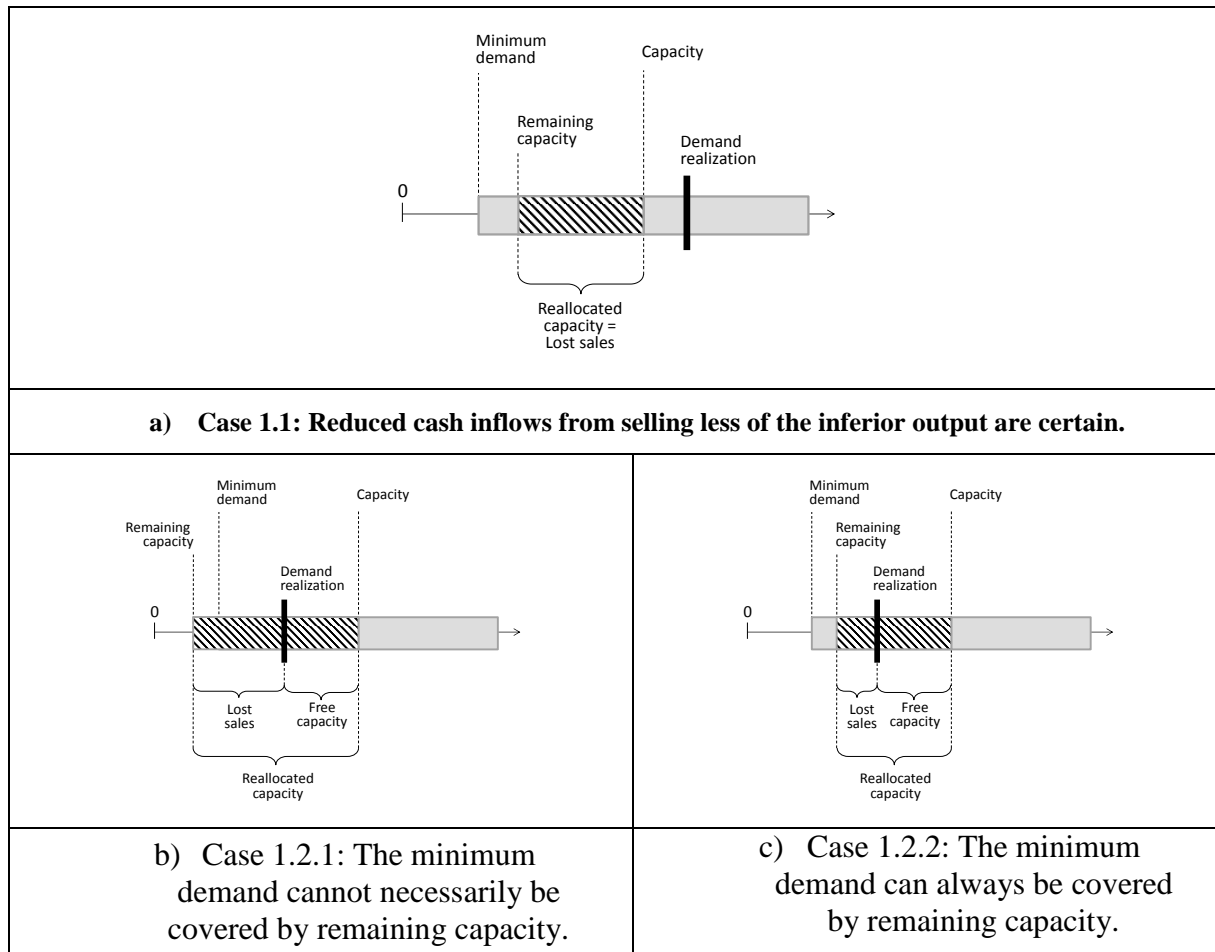


Abb. III-3 Exemplary illustration for the cases 1.1 and 1.2

III.2.3.2.2 Cash inflow effects of the superior process

As for the superior process, we consider the case where the demand for the superior output realizes below the capacity of the superior process and the demand for the inferior output exceeds the capacity of the inferior process (case 2.1). In this case, it is reasonable to reallocate free capacity of the superior process to the inferior process. Similar to the previous cases, the demand realizations for the superior process determine the level of realized flexibility. With the superior process being more profitable, the inferior process is only supported if free capacity is available. Analogous to the inferior process, the free capacity of the superior process $k_{sup} \in \mathbb{R}_0^+$ is uniformly distributed in $[0, D_{sup}^-]$ with a density function of $u(k_{sup}) = 1/D_{sup}^-$. By dividing the free capacity by the capacity of the superior process, the maximal realized flexibility f_{sup} of the superior process can be derived, which again is uniformly distributed with a density $u(f_{sup}) = C_{sup}/D_{sup}^-$.

The product of the maximal realizable flexibility of the superior process and its capacity equals the maximal capacity of the superior process that can be reallocated. Dividing it by the exchange rate turns the reallocated into received capacity and the maximal additional capacity for the inferior process can be derived. The maximal cash flow increases $p_{\max}(f_{\text{sup}})$ can be determined if the maximal additional capacity is multiplied with the profit margin of the inferior output and divided by the exchange rate.

$$p_{\max}(f_{\text{sup}}) = \frac{c_{\text{sup}} M_{\text{inf}}}{T} f_{\text{sup}} \quad (10)$$

Whether the maximal inflow increases are realized or not, depends on the excess demand $l_{\text{inf}} \in \mathbb{R}_0^+$ realization of the inferior process. Excess demand realizations below the maximal additional capacity can be covered completely. Thus, the inflow increases equal the excess demand multiplied with the profit margin of the inferior output. For excess demand realizations beyond the maximal additional capacity, the inflow increases are maximal $p_{\max}(f_{\text{sup}})$. As the density function $u(l_{\text{inf}}) = 1/D_{\text{inf}}^+$ is given due to the reproduction property of the uniform distribution, we can derive the expected inflow increases for a given level of realizable flexibility in Equation (11). The first addend equals the expected inflow increases for excess demands that can be covered completely. The second addend represents the expected inflow increases for excess demand realization beyond the maximal additional capacity.

$$\begin{aligned} E_{2.1}(p(f_{\text{sup}})) &= \int_0^{\frac{c_{\text{sup}}}{T} f_{\text{sup}}} l_{\text{inf}} M_{\text{inf}} u(l_{\text{inf}}) dl_{\text{inf}} + \left(1 - \frac{c_{\text{sup}}}{T D_{\text{inf}}^+} f_{\text{sup}}\right) p(f_{\text{sup}}) \\ &= \frac{M_{\text{inf}} c_{\text{sup}}}{T} \cdot f_{\text{sup}} - \frac{M_{\text{inf}} c_{\text{sup}}^2}{2T^2 D_{\text{inf}}^+} \cdot f_{\text{sup}}^2 \end{aligned} \quad (11)$$

To derive the expected periodic inflows $I_{\text{sup}}^{\text{periodic}}(F_{\text{sup}})$ that result from making the superior process more flexible, we integrate the expected inflows for a given level of realized flexibility (Equation 11) over the density of the realizable flexibility and we weight the intermediate result with the corresponding probability for case 2.1. Realizable flexibilities exceeding the flexibility potential are again compressed to one value.

$$\begin{aligned}
I_{\text{sup}}^{\text{periodic}}(F_{\text{sup}}) &= \text{Prob}_{2,1} \int_0^{F_{\text{sup}}} \left(\frac{M_{\text{inf}} C_{\text{sup}}}{T} \cdot f_{\text{sup}} - \frac{M_{\text{inf}} C_{\text{sup}}^2}{2T^2 D_{\text{inf}}^+} \cdot f_{\text{sup}}^2 \right) u(f_{\text{sup}}) df_{\text{sup}} \\
&+ \text{Prob}_{2,1} \left(1 - \frac{C_{\text{sup}}}{D_{\text{sup}}^-} F_{\text{sup}} \right) \left(\frac{M_{\text{inf}} C_{\text{sup}}}{T} \cdot F_{\text{sup}} - \frac{M_{\text{inf}} C_{\text{sup}}^2}{2T^2 D_{\text{inf}}^+} \cdot F_{\text{sup}}^2 \right) \quad (12) \\
&= \text{Prob}_{2,1} \frac{M_{\text{inf}} C_{\text{sup}}}{T} \cdot F_{\text{sup}} - \text{Prob}_{2,1} \left(\frac{1}{2T^2 D_{\text{inf}}^+} + \frac{1}{2D_{\text{sup}}^- T} \right) M_{\text{inf}} C_{\text{sup}}^2 \cdot \\
&F_{\text{sup}}^2 + \text{Prob}_{2,1} \frac{M_{\text{inf}} C_{\text{sup}}^3}{3T^2 D_{\text{sup}}^- D_{\text{inf}}^+} \cdot F_{\text{sup}}^3
\end{aligned}$$

III.2.3.3 Cash outflow effects of process flexibility

So far, we only analyzed the cash inflow effects of process flexibility. However, making processes flexible also leads to cash outflows. Cash outflows do not only depend on the level of process flexibility, but also on other factors, namely (a) cash outflows for project overhead such as administration and coordination, and (b) process-related characteristics such as the criticality of certain process steps and the similarity of both processes. Similar to the inflows, the outflows have to be calculated for each process separately. The difference is that, for the outflows, we can basically use the same function for both processes whereas the inflows required different functions. In this section, we demonstrate the cash outflow analysis for the inferior process.

First, process flexibility itself is analyzed. The idea of enabling a process to flexibly use its capacity is in line with the concept of flexibility-by-design (Schonenberg et al. 2008). Flexibility-by-design requires that various execution alternatives – in our case: producing the own output or the output of the superior process – have to be enabled. In line with our process understanding, process flexibility further requires resources and people of the company to be flexible (Sethi and Sethi 1990). The higher the desired level of process flexibility, the more flexibility projects have to be implemented. Implementing more flexibility projects also leads to cash outflows for administration and coordination, which increase over-proportionally with the project size (Verhoef 2002). In addition, a company is likely to implement the cheapest flexibility projects first. We model the properties of the cash outflows using the function $C_{\text{inf}} \cdot F_{\text{inf}}^2$. As one can see, the outflows increase with the desired level of process flexibility and capture the project overhead as the level of process flexibility is raised by the power of two. Of course, any larger exponent would fulfill the requirement of an over-proportional course as well. We chose to use a squared function as it keeps the optimization

problem analytically solvable, an approach inspired by Goyal and Netessine (2011). As for monetization, the cash outflows needed to make one capacity unit of the inferior process flexible, i.e., to enable the creation of T superior outputs, have to be incorporated. This factor highly depends on the processes at hand. In a worst-case scenario, the superior process has to be duplicated to enable the creation of the superior output on the inferior process. Although this worst case would most likely lead to prohibitively high cash outflows and, as a result, to an optimal level of process flexibility of zero, it is a reasonable starting point to calibrate the height of the cash outflows. Duplicating the superior process would lead to cash outflows that equal the initial investment of the superior process. By dividing these outflows by the capacity of the superior process and dividing the intermediate result with the exchange rate, we get the highest possible outflows for making one capacity unit of the inferior process flexible. The corresponding parameter is called scaling factor $G_{\text{inf}} \in \mathbb{R}^+$. The cash outflows that occur in the worst case scenario for a distinct level of process flexibility are $G_{\text{inf}} \cdot C_{\text{inf}} \cdot F_{\text{inf}}^2$.

When estimating the actual cash outflows for a distinct level of process flexibility, we use process-related characteristics to reduce the cash outflows of the worst-case scenario. Obviously, only those process steps that limit the capacity of the superior process have to be incorporated in the inferior process. We call these process steps critical. The more critical steps the superior process has, the more process steps have to be supported by the inferior process and the more expensive is the establishment of a distinct level of process flexibility. Thus, the first process-related characteristic that reduces the scaling factor is criticality. The criticality is inspired by the ideas from Gebauer and Schober (2006), and defined as the relation between the number of all process steps and the number of critical process steps of the superior process:

$$\frac{\sum \text{critical steps of the superior process}}{\text{all steps of the superior process}} \quad (13)$$

The next process-related characteristic is how similar the critical process steps of the superior process are with the counterparts – if available – from the inferior process. The more similar the critical process steps and their counterparts, the less outflows occur for establishing a distinct level of process flexibility. Therefore, the similarity s (with $0 \leq s \leq 1$) between a critical process step of the superior process and its counterpart in the inferior process also reduces the scaling factor. To present an approach for determining similarity, we refer to the concept of variability introduced by Gebauer and Schober (2006). They rely on the Lorenz curve to derive the concentration of process variants (i.e., different execution paths of a

process). The higher the concentration of the process variants, the lower is the need for process flexibility. As Gebauer and Schober focus on one process instead of two, this concept has to be adjusted to fit into our model. We therefore use the frequency distribution of the variants of the superior process to determine to what extent a critical process step of the superior process is already supported by the inferior process. Consider that a critical process step i has n_i different variants $v_{i,j}$. The variants of this step occur with a frequency $p(v_{i,j}) \in [0,1]$. To obtain the similarity, we introduce a decision variable $d(v_{i,j}) \in \{0,1\}$ that equals 0 if the variant $v_{i,j}$ of the critical process step i can only be produced by the inferior process after a flexibility investment and 1 if the variant can already be produced. The decision variables are weighted with the occurrence probability of the corresponding variant and cumulated over the variants n_i :

$$s_i = \sum_{j=1}^{n_i} p(v_{i,j}) \cdot d(v_{i,j}) \quad (14)$$

When multiplying the criticality measure with the scaling factor, we get an estimate for the cash outflows by implicitly assuming that each process step is equally expensive to install. This estimate, however, does not consider that similar process steps do not create outflows. By subtracting the similarity measure from 1, we get a standardized variable that reflects the non-similarity of a critical process step, a quantity that is responsible for cash outflows. Summing up these non-similarity measures over all critical process steps weights the critical process steps with their similarity and, thus, is a reasonable estimate for adjusting the scaling factor. In the following, we use the process factor r_{inf} that adjusts the scaling factor not only for non-critical process steps, but that also incorporates the similarity of both processes.

$$r_{\text{inf}} = \frac{\sum_{i \in \text{critical process steps}} (1 - s_i)}{\text{all steps of the superior process}} \quad (15)$$

By multiplying the process factor and the scaling factor, the cash outflows for making a single capacity unit of the inferior process flexible can be estimated as the scaling factor, defined as the worst-case outflows for a given level of process flexibility, is adjusted based on the process characteristics that naturally support process flexibility. To obtain an estimate for the cash outflows, the product of the process factor and the scaling factor has to be multiplied with $C_{\text{inf}} \cdot F_{\text{inf}}^2$.

$$C(F_{\text{inf}}) = G_{\text{inf}} \cdot C_{\text{inf}} \cdot F_{\text{inf}}^2 \cdot r_{\text{inf}} \quad (16)$$

To derive the outflows of the superior process, the same approach can be applied. The scaling factor can be obtained by dividing the initial investment of the inferior process through its capacity and by multiplying the intermediate result with the exchange rate. As for the criticality, the critical steps of the inferior process are decisive instead of the critical steps of the superior process. With similarity being a double-sided measure, the approach applied here can directly be copied.

III.2.3.4 Solving the optimization model

To find the optimal levels of flexibility for the superior and the inferior process, we calculate the risk-adjusted expected NPV. As the cash outflows occur at the beginning of the planning horizon, they need not be discounted. The risk-adjusted expected NPV of the cash inflows can be derived by the discounting of the expected additional inflows per period. For a constant risk-adjusted discount rate $i \in \mathbb{R}^+$ and a planning horizon of $N \in \mathbb{N}$ periods, the discount factor $\delta \in \mathbb{R}^+$ can be calculated by the formula of the partial sum of a geometric sequence.

$$\delta = \frac{1 - \left(\frac{1}{1+i}\right)^{N+1}}{\frac{i}{1+i}} \quad (17)$$

The optimum of the objective function is characterized by the equality of the marginal inflows and the marginal outflows. As the marginal outflows are strictly increasing and strictly convex and the marginal cash inflows are strictly decreasing, there is exactly one optimum, i.e., a global maximum. For the optimal flexibility of the inferior process, it has to be taken into consideration that there are different objective functions due to the technical case distinction we had to introduce for case 1.2. Whether the optimum is located in the first or in the second definition range cannot be forecasted without knowing concrete values for the model parameters. Thus, two optimality conditions must be derived. The detailed derivations are depicted in the appendix.

$$\begin{aligned} \text{For } F_{\text{inf}} \leq \frac{D_{\text{inf}}^-}{C_{\text{inf}}}; F_{\text{inf}}^* = & \\ = \frac{\frac{2M_{\text{sup}}C_{\text{inf}}T^2}{D_{\text{sup}}^+} \text{Prob}_{1.1} + \frac{2Gr}{\delta} + \frac{C_{\text{inf}}M_{\text{inf}}}{D_{\text{inf}}^-} \text{Prob}_{1.2} - \frac{M_{\text{inf}}C_{\text{inf}}T}{D_{\text{sup}}^+} \text{Prob}_{1.1}}{\frac{2C_{\text{inf}}^2TM_{\text{inf}}}{D_{\text{inf}}^-D_{\text{sup}}^+} \text{Prob}_{1.2}} & \\ = \frac{\sqrt{\left(-\frac{M_{\text{sup}}C_{\text{inf}}T^2}{D_{\text{sup}}^+} \text{Prob}_{1.1} - \frac{2C_{\text{inf}}T_{\text{inf}}}{\delta} - \frac{C_{\text{inf}}M_{\text{inf}}}{D_{\text{inf}}^-} \text{Prob}_{1.2} + \frac{M_{\text{inf}}C_{\text{inf}}T}{D_{\text{sup}}^+} \text{Prob}_{1.1}\right)^2 - \text{Prob}_{1.2} \frac{4C_{\text{inf}}^2TM_{\text{inf}}}{D_{\text{inf}}^-D_{\text{sup}}^+} \cdot (\text{Prob}_{1.1}M_{\text{sup}}T - \text{Prob}_{1.1}M_{\text{inf}})}}{\frac{2C_{\text{inf}}^2TM_{\text{inf}}}{D_{\text{inf}}^-D_{\text{sup}}^+} \text{Prob}_{1.2}} & \end{aligned} \quad (18a)$$

$$\text{For } F_{\text{inf}} > \frac{D_{\text{inf}}^-}{C_{\text{inf}}}: F_{\text{inf}}^* = \frac{\text{Prob}_1 \cdot (M_{\text{sup}}T - M_{\text{inf}})}{\frac{C_{\text{inf}}T}{D_{\text{sup}}^+} \cdot \text{Prob}_1 \cdot (M_{\text{sup}}T - M_{\text{inf}}) + \frac{2G_{\text{inf}}r_{\text{inf}}}{\delta}} \quad (18b)$$

$$F_{\text{sup}}^* = \frac{\frac{C_{\text{sup}}}{TD_{\text{inf}}^+} + \frac{C_{\text{sup}}}{D_{\text{sup}}^-} + \frac{2TG_{\text{sup}}r_{\text{sup}}}{\text{Prob}_{2.1}\delta M_{\text{inf}}} - \sqrt{\left(-\frac{C_{\text{sup}}}{TD_{\text{inf}}^+} - \frac{C_{\text{sup}}}{D_{\text{sup}}^-} - \frac{2TG_{\text{sup}}r_{\text{sup}}}{\text{Prob}_{2.1}\delta M_{\text{inf}}}\right)^2 - 4\frac{C_{\text{sup}}^2}{TD_{\text{sup}}^-D_{\text{inf}}^+}}}{2\frac{C_{\text{sup}}^2}{TD_{\text{sup}}^-D_{\text{inf}}^+}} \quad (19)$$

III.2.4 Real-world application in the service sector

In our previous work (Afflerbach et al. 2013), we applied a less developed version of the optimization model to the wafer production processes of a company from the semi-conductor industry. In that case, process flexibility was achieved by investing 3,000,000 EUR in a multi-purpose machine whose capacity could be used to produce a basic and a sophisticated wafer on the inferior process. We showed that the investment in process flexibility was reasonable. By comparing the investment outflows with the sales effects, we also found that a machine with a smaller capacity would have been sufficient to cover the forecast demand and would have implied cost savings of 600,000 EUR.

As we aimed at developing a model for process flexibility that fits several application domains, we now demonstrate how to apply the model in the service sector. Such a demonstration is worthwhile because process flexibility has to be achieved by different projects in the service sector. While, in the manufacturing context, flexibility can be achieved by multi-purpose machines, it depends much more on people and their skills in the service sector. We report on how we determined the optimal levels of flexibility for the coverage switching processes of a financial service provider that intended to achieve process flexibility by multi-skilling. We first provide information on the case context and then determine the optimal levels of process flexibility using the optimization model.

The case company is a leading insurance broker pool from the German-speaking countries that supports insurance brokers in their daily business by taking over back-office activities (e.g., communication with insurance companies or administrating contracts). In return, the case company charges proportional provisions. As typical for a service provider, the case company has a predisposition for investing in process flexibility as services cannot be stored. This

property makes it impossible to cover excess demand by inventory buffers and, thus, requires flexibility to be implemented in the processes themselves.

Coverage switching processes adhere to the following blueprint: In case an insurance broker acquires a new customer, the customer's current insurance situation is analyzed for potential improvements in premiums and risk coverage. It is important to find out whether the customer's current contracts contain special conditions and whether her risk situation disables her to be served by a potentially better insurance. For example, a homeowner's insurance cannot be switched if the respective residential building has aged pipes. In fact, most insurers reject a customer if the pipes have reached a certain age as the risk for such pipes to break is considered very high. If a current contract can be favorably switched, the case company must update the information about relevant risk factors, a task that is required by the new insurer for accepting the customer. Finally, the department has to cancel the current contract and to buy the new contract.

The case company operates two coverage switching processes, one for homeowner's insurances and another for accident insurances. The process that deals with homeowner's insurances is the inferior process. As each insurance type requires specific in-depth knowledge, both processes are executed by separate employees. In order to be able to react more flexibly upon fluctuating demand, the case company intended to train some employees such that they can conduct the coverage switching process for both insurance products. We applied the optimization model to determine the optimal levels of process flexibility and, on that foundation, derive the optimal skilling profile of the involved employees.

The input data about the capacity strategy, the process factors, and the demand distribution (including the demand boundaries) were provided by the head of the department that is responsible for the coverage switching process (Tab. III-2). The case company sets its capacities equal to the expected demands. As both processes have the same demand distribution, they have the same capacity. Regarding the profit margins, service times, and training costs, the coverage switching process is more complex for the homeowner's insurance. The reason is that a homeowner's insurance is a bundle of fire, windstorm, glass breakage, and burst pipe insurances, a fact that requires more complex analyses than an accident insurance. The higher complexity leads to longer service times, lower profit margins, and higher training costs. Each process was executed by two employees. Considering the different service times, we were surprised that both processes had identical capacities and were executed by the same number

of employees. The reason was that the employees of the process for accident insurances were not only responsible for the coverage switching process, but also for other processes. The case company typically used a planning horizon of $n = 7$ years and a yearly risk-adjusted interest rate $i = 0.04$ for investment decisions.

Tab. III-2 Input data

Parameters	Homeowner's insurance (inferior process)	Accident insurance (superior process)
Capacity ($C_{inf/sup}$)	200 executions p.m.*	200 executions p.m.
Expected demand ($X_{inf/sup}$)	200 executions p.m.	200 executions p.m.
Upper boundary for the demand ($C_{inf/sup} + D_{inf/sup}^+$)	250 executions p.m.	250 executions p.m.
Lower boundary for the demand ($C_{inf/sup} - D_{inf/sup}^-$)	150 executions p.m.	150 executions p.m.
Profit margin ($M_{inf/sup}$)	40 EUR per execution	100 EUR per execution
Service time	1 hour per transaction	0.5 hours per transaction
Number of employees staffed	2 employees	2 employees
Training costs	15,000 EUR per employee	10,000 EUR per employee

* p.m. = per month

Whereas the values for most input parameters could be observed directly, the exchange rate, the cash outflows, and the probabilities of occurrence for the cases introduced in Abb. III-2 had to be assessed separately. The exchange rate results from the relationship between the service times of both processes. It equals $T = 1 \text{ h}/0.5 \text{ h} = 2$. As for the cash outflows, we had to determine the process and the scaling factor of both processes. Taking the process for homeowner's insurances as example, training both employees leads to outflows of 30,000 EUR and to a flexibility potential of $F_{inf} = 100 \%$. Based on these considerations, we can calculate the combined process and scaling factor $G_{inf} \cdot r_{inf} = 150 \text{ EUR}$ based on the outflow function (Equation 16). For the process that deals with accident insurances, the combined process and scaling factor is $G_{sup} \cdot r_{sup} = 100 \text{ EUR}$. As the demand scatters symmetrically around the capacities, the probabilities of the cases introduced in Abb. III-2 equal 50% each. Like in our previous case from the semi-conductor industry, the input parameters could be assessed easily. Having finished the data collection, we applied the optimization model to identify the optimal levels of process flexibility. In the case at hand, process flexibility could not be treated as a continuous variable because of the small number of employees per process. The case company could only establish 50 % or 100 % flexibility for each process. Thus, we did not apply Equations (18a), (18b), and (19) to determine the continuous optima. Instead, we used the

objective function of the optimization model to calculate the risk-adjusted expected NPV of each decision alternative (Tab. III-3). The results indicate that, in the case at hand, investments in process flexibility are always more profitable than leaving the status quo unchanged. Multi-skilling one employee per process leads to an economically optimal solution and a risk-adjusted expected NPV of about 82,000 EUR. To provide guidance for larger departments, we also show the exact continuous optima at the end of this section.

Tab. III-3 Risk-adjusted expected NPVs for the different decision alternatives

$F_{\text{inf}}/F_{\text{sup}}$	0 %	50 %	100 %
0 %	0 EUR	14,778 EUR	4,778 EUR
50 %	67,078 EUR	81,857 EUR (*)	71,857 EUR
100 %	52,078 EUR	66,857 EUR	56,857 EUR

By applying the optimization model to the case company, we also gathered novel insights into the relationships among the input parameters. We found that the maximum demand deviation serves as an upper boundary for the flexibility potential. Regarding the process for homeowner's insurances, a flexibility potential of 12.5 % and beyond causes the same cash inflow effects. The reason is that the case company can cover the maximum demand with that level of process flexibility. As this level of process flexibility is below the threshold from the case distinction (i.e., $D_{\text{inf}}^-/C_{\text{inf}} = 25\%$), the expected additional inflows for a process flexibility of 50 % and 100 % can be calculated by inserting 12.5 % into Equation (7). The differences in the risk-adjusted expected NPV result from the outflows for training differently many employees. The same argumentation holds true for the process that deals with accident insurances. Here, the critical level of process flexibility is 25 % due to the specific exchange rate.

For processes with a larger number of employees, where process flexibility can be treated as a continuous variable, Equations (18a), (18b), and (19) can be applied to determine the optimal levels of process flexibility. With the given parameter values, the coverage switching process for homeowner's insurances would have 12.43 % of process flexibility. This value is very close to the process flexibility that is required to completely support the process for accident insurances. Regarding the process for accident insurances, the optimization model determines 22.3 % as optimal level of process flexibility. Again, this result is plausible as it is very close to the flexibility value that enables completely supporting the other process. In this case, the

optimal results are located close to their reasonable maxima, a circumstance that shows that flexibility is relatively cheap and that the case company greatly benefits from respective multi-skilling investments.

III.2.5 Conclusion

In this paper, we presented an optimization model to determine the optimal level of process flexibility, which we define as the fraction of the capacity that can be reallocated from one process to another. The model meets the shortcomings of previously proposed approaches regarding the economic valuation of process flexibility as it puts particular emphasis on the positive economic effects of process flexibility. The model relies on risky demand as well as further process characteristics such as criticality, similarity, and variability. By considering the cash effects of process flexibility, a multi-period planning horizon, and a risk-adjusted interest rate, the model complies with the principles of value-based BPM. Finally, we demonstrated the model's applicability using the coverage switching processes of an insurance broker pool provider as example.

The optimization model is beset with the following limitations that should be subject to further research: First, in line with our objectives, we made some simplifying assumptions, i.e., the focus on two processes as well as the independent and uniformly distributed demand. This setting, however, enabled us structuring the optimization problem at hand, identifying relevant parameters and their economic effects as well as analytically determining an optimal level of process flexibility. The optimization model could also be easily applied in industry and helped extend industrial decision-making capabilities. However, further research should explore which assumptions can be relaxed and how the insights gained so far can be generalized. For example, the optimization model should be extended to more than two processes and different demand distributions. Second, paying much attention to the positive economic effects of process flexibility, we modeled the cash outflows in rather a coarse-grained manner. Future research should therefore strive for a more sophisticated modeling that also includes further process characteristics that drive process flexibility.

III.3 Beitrag 4: „Determining the Business Value of Volume Flexibility for Service Providers – A Real Options Approach “

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Zusammenfassung

Service Providers often struggle with fluctuating demand of service requests which can lead to prolonged waiting times and hence to dissatisfaction of customers. Therefore, service providers strive for volume flexibility to cope with this challenge. In manufacturing context, a shift of excess demand to an external partner is already common practice while service providers reacted reluctantly to this possibilities in fear of high integration costs. The uprising of new technologies such as Service Oriented Architectures (SOA) lowered these cost and allowed the separation of up to now entangled software functionalities into services and the use of standardized interfaces. Nevertheless, investment decisions related to SOA oftentimes lack a well-founded valuation of the respective benefits. Therefore, we present an analytical model based on the Real Options Approach (ROA) that determines the business value of flexibility resulting from an IS-based integration of an external service vendor. Thereby we consider the trade-off between the investments into the technical requirements (e.g. SOA) that are necessary to gain volume flexibility on the one hand and the negative effects of unsatisfied customers on the customer equity on the other hand. We also provide first insights into the applicability of the model via a demonstration example.

III.3.6 Introduction

The main objective of service providers is to conduct services for their customers in order to raise the customer equity and thus their own business value (Kumar and George 2007). There are many attempts to define the term “services” (e.g. Rai and Sambamurthy 2006, Fitzsimmons and Fitzsimmons 2010), but according to Johnston et al. (2012) their three essential characteristics are immateriality, inseparability of production and consumption, and the integration of the customer into the value creation process. As a consequence, services cannot be stored (Fitzsimmons and Fitzsimmons 2010), which makes the business of the service provider strongly sensitive with respect to time. In what way this time sensitiveness affects the service providers’ business value and how a service provider can deal with it is addressed in this paper.

Services are oftentimes initiated by customers (“service requests”) and afterwards processed by the service provider, which takes time and requires capacity, before the service is finally returned to the customer. Service providers thereby face the challenge of uncertain demand since they don’t know when customers initiate how many service requests. At the same time, service providers oftentimes possess fixed internal capacities to process the service requests in the short term. Thus the combination of a limited capacity and uncertain demand can result in prolonged waiting times for customers. Customers are sensitive with respect to the total service time (e.g. Ray and Jewkes 2004), i.e. the time from a service request until the delivery of the service. If the total service time exceeds a certain time limit, customers may become dissatisfied and are more likely to switch their service provider. Since treating customers as assets is one key success factor for companies (e.g. Kumar et al. 2004), the impact of the total service time on the customer satisfaction – and thus on the long-term success of their business – is essential for service providers (Nguyen and Mutum 2012).

In general, service providers possess two ways to deal with the uncertain demand: First, a service provider can directly influence the demand of customers. This can be accomplished by means of revenue management, like e.g. dynamic pricing (Phillips 2005), bounding the number of service requests, or by marketing procedures. Second, a service provider can set up its supply side so that it is able to flexibly react on volatile demand. Since volatile demand can lead to either capacity shortages or idle times, a service provider might use methods of capacity management to cope with this challenge. Those methods include e.g. cross-training of

employees, sharing of (companies' internal) capacities, using part-time employees, increasing customer participation, and work shift scheduling (Fitzsimmons and Fitzsimmons 2010).

To cope with the aforementioned challenges, this paper deals with providing flexibility on the supply side through the use of enabling information systems (IS). As we mentioned above, service providers' (internal) capacities are often fixed, so that we need to add temporary additional, external capacity to cover the demand fluctuations. As source for this additional capacity, we consider the temporary integration of an external service vendor², who offers volume-based contracting of capacity (Aksin et al. 2008). A respective integration of external vendors by means of IS used to be accompanied with huge technical efforts resulting in high cash outflows. However, the rising application and market penetration of Service Oriented Architectures (SOA) reduced the efforts enormously (Kohlmann and Alt 2010). As of today, standardized interfaces simplify the technical integration of external vendors. Consequently, a facilitated third party integration is considered to be one of the main advantages of SOA (Becker et al. 2011).

Scientific literature reveals that technical challenges related to SOA were rather discussed than its business value (Beimborn et al. 2008). Although there are a few articles that consider the business value of SOA by identifying and providing indicators for benefits of SOA, a formal model that supports the determination of the business value of SOA is still missing (Beimborn et al. 2008, Kryvniska et al. 2011). We address this research gap by valuating a specific kind of benefit which can be achieved by investments in SOA. To be more specific, we evaluate the business value of flexibility resulting from the integration of an external service vendor. Therefore, we answer the following research question:

“What is the business value of flexibility resulting from an IS-based integration of an external vendor?”

By answering this research question, we explicitly focus on the trade-off between the investments into the technical requirements (e.g. SOA) that are necessary to gain volume flexibility and the negative effects of unsatisfied customers on the customer equity. From a research perspective, our model extends knowledge on how to value IS-investments such as SOA by considering the daily business of companies as well as indirect effects such as negative effects on customer equity. Practitioners in departments such as strategic workforce are enabled

² For simplicity reasons, we speak in the following of an “external vendor”.

to value the inclusion of external service vendors while IT departments can justify IS-investments by using our model. Finally, strategic decisions in top management such as flexibility improvements can be valued in a better way by applying our model.

The remainder of the paper is organized as follows. We first describe shortly the role of SOA in the embedding of external vendors in subsection 2.1. Since there is a lot of research about flexibility and its definitions, we derive a definition that fits our problem in subsection 2.2. Section 2 concludes with a discussion of relevant literature on how to determine the business value of the integration of external vendors. Based on these findings, we develop an analytical model using the real options approach (ROA) to determine the business value of flexibility resulting from an IS-based integration of an external vendor in section 3. In section 4 we demonstrate the applicability of our model by providing a real world case of a large German insurance company. Finally, section 5 concludes the paper and discusses its limitations.

III.3.7 Theoretical Background

III.3.7.1 The Role of IS for the Integration of External vendors

While the integration of partners into the value chain is common practice in the manufacturing context, service providers lacked this kind of cooperation in the past decades. One major reason was the expectation of very high costs of integration. Recent developments of new technologies such as unified interfaces, Web Services, and SOA lowered these costs (Häckel and Dorsch 2012; 2014). Although there are other means (such as cloud computing or cross-company workflow management systems) that allow for cooperation among companies, we focus on SOA as our main example for an IS-based integration of a service vendor since it can be seen as a powerful underlying and enabling concept e.g. for cloud computing (Vouk 2008). SOA allows the isolation of up to now inseparable software functionalities into services. These services are well defined, self-contained modules that provide standard business functionality. Thereby, the services are independent from other services and their state or context. They are loosely coupled which means they communicate with each other requesting execution of their operations and can therefore be arranged in varying order or different contexts (Fremantle et al. 2002). Services furthermore have published interfaces, which are inviolable by other services. This implies that the services invocation is independent from the underlying infrastructure, the used protocol, and from being local or remote (Papazoglou et al. 2007). These characteristics enabled the uprising of new business models in the service industry which aim at outsourcing

business processes to external vendors or embedding service vendors into the own value chain. SOA is therefore considered as an enabler for the allocation of business activities among business partners (Chesbrough and Spohrer 2006). This also requires an alignment of the technological and the business perspective (Steen et al. 2005) and the deduction of technological requirements from the business (Kohlmann and Alt 2010). Therefore, key challenges beyond the use of standardized interfaces include a common policy management, governance, and authentication, which need to be considered while still being able to maintain lightweight implementation and deployment of web services (Arrott et al. 2007). To meet these requirements, investment decisions have to be evaluated from both a technical and an economic perspective. However, if those investments are made, they enable service providers to flexibly react to core challenges such as fluctuating demand. The next subsection therefore presents a general overview of the characteristics of flexibility and discusses a specific type of flexibility, namely volume flexibility, in greater detail.

III.3.7.2 Relevant Types of Flexibility for Service Providers

Although a large amount of research focused on flexibility throughout the last decades, flexibility is still an uncompleted topic in research (Saleh et al. 2009, Neuhuber et al. 2013). Due to the complexity and context dependency flexibility is not easy to define, to categorize, and to measure. Sethi and Sethi (1990) identified about 50 different definitions for (manufacturing) flexibility, but the concept of flexibility is of course not limited to the manufacturing context. In the following, we go in line with Neuhuber et al. (2013) and generally consider flexibility as “the capability of a system to react to or to anticipate system or environmental changes by adapting its structure and/or its behavior considering given objectives” (Wagner et al. 2011, p. 811). Scientific literature basically agrees on a basic set of types of flexibility, i.e. new product, volume, product, and delivery flexibility.

As we mentioned in the introduction, we need a type of flexibility that is capable to cope with volatile demand on the capacity management side. This is necessary since customers are only willing to wait to receive their services for a certain period of time before they get dissatisfied, which forces service providers to be able to process more service requests in peak times. Due to that we consider volume flexibility in this paper, which is defined as “ability to change the level of aggregated output” (Oke et al. 2005, p. 975). Note that this definition is not limited to the manufacturing context but includes services as well. Since we are further focusing on getting this additional capacity from an external vendor, we are able to specify our

understanding of flexibility. First, we complement the very broad definition of volume flexibility by adapting ideas of routing flexibility (Oke et al. 2005, Sethi and Sethi 1990), which is the ability to produce the same service on different capacities or by alternate routes through the service process (Oke et al. 2005). We also aim at addressing the challenge of fluctuating demand by using alternate routes of service fulfilment, which are based on the (temporary) integration of an external vendor. Therefore, the idea of vendor flexibility also becomes relevant. Vendor flexibility is defined as “the specific types of flexibility relating to individual vendors that support ... [service production and service delivering] operations” (Gosling et al. 2009, p. 2). Consequently, the specific type of volume flexibility considered in this paper is defined as:

The ability to create process outputs using both pre-installed, internal capacity as well as temporarily volume-based contracting, i.e. additional capacity offered by an external vendor.

This type of volume flexibility can be created by a temporary integration of an external vendor through standardized interfaces, e.g. through SOA. However, this course of action also creates associated cash outflows. Therefore, the question arises, how the benefits of gaining this type of volume flexibility compare to the respective cash outflows. In order to derive a sound investment decision about whether or not to invest, a monetary valuation of the benefits of the investment, i.e. the value derived from the created volume flexibility, has to be assured in order to compare them to the corresponding cash outflows. Therefore we discuss approaches that monetarily value the benefits of volume flexibility in the next subsection.

III.3.7.3 Determining the Business Value of Volume Flexibility

In the context of valuating volume flexibility one has to take care to distinguish between the economic valuation of an investment into its creation and the measurement of the degree of flexibility (Saleh et al. 2009). For a discussion of the latter one see e.g. Gupta and Goya (1989). In this paper we focus on the business value of the investment into the creation of volume flexibility under consideration of our particular focus on the customers' lifetime value. The value of integrating an external vendor to gain volume flexibility, i.e. to be able to handle uncertain demand, has been discussed in many different contexts and different approaches emerged within literature. Therefore, we will discuss some of the most influencing works for this manuscript in the following.

In our paper, we consider a random arriving process of service requests which is then processed by a number of agents who service the process. Papers in operations research literature, especially those in queuing theory also address this initial situation (for a comprehensive review of queuing theoretic approaches see for example Gans et al. (2002)). Following this idea, Whitt (2006) present a queuing model which is able to determine optimal internal staffing levels and overall performance of the queuing system and therefore lacks a consideration of external vendors for services. Moreover, although the model considers the possible abandonment of customers, it does not explicitly takes indirect negative affects initiated through unprocessed service requests of customers into account. Aksin et al. (2008) analyze a contract choice problem between volume- and capacity based contracts. They use a game theoretic approach instead of a queue theoretic approach, to be able to find optimal capacities and prices between the two players, i.e. the service provider and the external vendor, with respect to both contracts. Addressing the shortcomings of Whitt (2006), they explicitly model the flexible embedment of a service vendor. Still, they neglect initial cash-outflows related to contracting issues and negative effects on customers. In contrast, Ren and Zhou (2008) deal with customer satisfaction in the context of service quality and outsourcing contracts. Nevertheless, they focus on contracting issues between the company and the services vendor and only consider a complete capacity shift or no capacity shift at all. Moreover, they abstract from initial cash outflows for realizing a contract.

Not explicitly grounded in the queuing theory but addressing a very similar problem, Häckel and Dorsch (2013) provide an optimization model allowing for the simultaneous consideration of different types of capacity supply. Thereby the flexible on-demand integration of external vendors is also considered. To apply their model, a discrete event simulation of a queuing system is necessary. A similar and thus also numerical approach to evaluate the embedding of an external vendor in times of demand peaks is found in Braunwarth and Ullrich (2010). Nevertheless, simulations of random processes deliver (pseudo-)random solutions, thus different repetitions of the simulations might lead to different solutions and thus to different insights and decisions. Moreover, companies need to put much effort in the conduction of simulations. The fact that simulations don't allow for easy sensitivity analyzes further limit their practical use. Therefore, an analytical approach – and thus a closed form solution – might be better to use in practice (Wang and De Neufville 2005).

Such an analytical approach is provided by Neuhuber et al. (2013). The authors develop a model that determines the business value of volume and functional flexibility and further provides an optimization model for the best mixture of both. However, although the authors focus on time sensitivity of customers, the model does not include negative effects on the customer equity (i.e. the sum of all customer lifetime values) as described above.

Benaroch et al. (2010) develop an analytical decision model that deals with the valuation of flexible IT-service contracts in the context of IT-outsourcing. Through these contracts an IT service provider is able to outsource all of its service requests to a vendor. Therefore, they address a problem that is quite similar to the one considered in this paper. To analytically evaluate the contracts the authors apply the real options approach (ROA). Several authors agree that – despite of many obstacles that come along with its application – ROA can be a useful approach to determine the value of flexibility (see e.g. Copeland and Antikarov 2003, Amram and Kulatilaka 1998, Trigeorgis 1996). Fichman et al. (2005) describe six types of real options applied in the IS field, that is the option to stage, to abandon, to defer, to have strategic growth, to change scale and to switch. For the purpose of this paper the option to change scale, that means e.g. to extend or contract allocated resources, fits very well to our context.

Bengtsson (2001) provides a good overview about the use of ROA to quantitatively value different types of (manufacturing) flexibility based on the classification of Sethi and Sethi (1990). He revealed that e.g. Tannous (1996) evaluates volume flexibility in the context of manufacturing using ROA. The articles written by Tannous (1996) and by Benaroch et al. (2010) therefore aim at a similar direction, i.e. an analytical valuation of volume flexibility based on ROA. However, Tannous' (1996) approach focuses on determining the optimal number of (internal) machines, so he does not consider the integration of an external vendor to provide volume flexibility as we do in this paper. Benaroch et al. (2010) in contrast explicitly focus on the integration of an external vendor, but there is still a major distinction from our paper: The authors consider flexibility as a binary decision either to outsource all or none service requests. Since this kind of flexibility is rather limited, we try to determine the number of service requests to be outsourced according to the corresponding customer satisfaction, which is determined through the customers' time sensitiveness and more importantly – as we stated above – is a major driver of business decisions for service providers.

Therefore, the aim of this paper is to develop a model based on ROA that helps to determine the business value of the creation of volume flexibility through an IS investment. This volume

flexibility is established through the integration of an external vendor into the processing of service requests in order to avoid unsatisfied customers.

III.3.8 Determining the Business Value of Volume Flexibility for Service Providers

III.3.8.1 General Setting

On the intersection of uncertain demand and supply, we propose a model based on ROA to evaluate the option of a service provider to shift an arbitrary number of service requests to an external vendor. ROA is chosen because it is a common tool to value flexibility in the context of information systems (e.g. Ullrich 2013) and it offers the possibility to solve the problem in a closed form solution (through the Black Scholes Model). The model itself is based on the real world idea that a service provider has to deal with uncertain demand for services, but possesses a fixed internal capacity, which may lead to long processing times for service requests in times of high demand. Due to their time sensitiveness customers may become unsatisfied, which can be expressed as negative effects on their customer equity. Therefore, investing into standardized interfaces in order to integrate an external vendor to process service requests in peak times can be beneficial for the service provider, although it is associated with upfront investment costs. Thereby the external vendor is assumed to offer arbitrary high, volume-based contracted capacity, that is, a volume dependent capacity with a fixed price per service request. The model we develop in this chapter is able to account for this trade-off and determines the value of the option to shift service requests to the external vendor.

III.3.8.2 Connection between the Amount of Service Requests, the total service time, and Customer Satisfaction

We consider a service provider that offers highly repetitive and standardized services. These services are initiated by randomly arriving service requests from customers. The service provider processes service requests continually with respect to the internal capacity determined by the available service stations (i.e. employees and machines). Due to the inseparability of production and consumption of services, the service provider cannot split one service to be processed in different service stations at the same time. If the number of service requests exceeds the capacity of the service stations, the processing of the exceeding service requests has to wait. Given that situation we assume:

(A1) The service requests are processed parallel in $s \in \mathbb{N}$ service stations according to the “first come first serve” principle.

(A2) The service provider’s capacity (i.e. the number of service stations) has already been set in the past based on the expected arrival rate of service requests.

All service requests that are being or waiting to be processed by the service provider are said to be *in the service provider’s system*. Arriving service requests are considered to be Poisson distributed, with a positive drift μ . At the same time, the service provider is able to linearly process service requests according to its internal capacity, which is based on the expected value of the arrival rate. Given this situation, the superposed process of service requests in the service providers’ system is assumed to have zero drift, i.e. $\mu = 0$, but a non-vanishing standard deviation $\sigma > 0$.

(A3) The total amount of service requests in the service providers’ system $n: \mathbb{R} \rightarrow \mathbb{N}$ evolves, according to a superposed Poisson process with zero drift.

The time a service request stays within the service provider’s system is named total service time. It starts when a customer requests a service and ends when the service is fulfilled. The total service time consists of pure processing time to handle a service plus waiting time until the processing begins.

In conclusion the total service time of a service request on the one hand depends on the number of service stations $s \in \mathbb{N}$. On the other hand it depends on the amount of service requests $n(t) \in \mathbb{N}_0$ in the service providers’ system at time $t \in \mathbb{R}$. Therefore, the total service time should be denoted as $T = T_s(n(t))$. Since we consider a highly standardized type of service, we assume:

(A4) The pure processing time to handle one request in a service station, i.e. $T_1(1)$, is constant, equal and known with respect to all service requests.

The total service time $T_s: \mathbb{N}_0 \rightarrow \mathbb{R}_0^+$, respecting the waiting time plus the processing time of the service requests, in general is given by

$$T_s(n(t)) = \left\lceil \frac{n(t)}{s} \right\rceil \cdot b, \quad (1)$$

where $\left\lceil \frac{n(t)}{s} \right\rceil := \min\{k \in \mathbb{Z} \mid \frac{n(t)}{s} \leq k\}$ and $b := T_s(1) \in \mathbb{R}_0^+$ denotes the constant processing time for one service request.

The total service time is an important factor that determines the perceived service quality from the customers' perspective: An unforeseen rise (fall) in the total service time may lead to unsatisfied (satisfied) customers (Ho et al. 2006). Therefore we can state that customers become unsatisfied if the amount of service requests in the service provider's system exceed a critical number $n_{\text{crit}} \in \mathbb{N}$ and thus a critical total service time $T_s(n_{\text{crit}}) =: t_{\text{crit}}$. Certainly, customers behave and act highly individual, such that the critical service time may be different for each customer. Hence, we consider the critical service time for an average customer. To be able to handle this the service provider has to estimate this time, e.g. through experience from historical data. Therefore we assume:

(A5) The critical total service time $T_s(n_{\text{crit}}) = t_{\text{crit}}$ is known, fixed, and equal for all service requests and thus for all customers.

Thus a necessary condition for satisfied customers is

$$T_s(n(t)) \leq t_{\text{crit}}, \quad (2)$$

whereas the critical number of service requests is given by

$$n_{\text{crit}} = \left\lfloor s \cdot \frac{t_{\text{crit}}}{b} \right\rfloor, \quad (3)$$

where $\left\lfloor s \cdot \frac{t_{\text{crit}}}{b} \right\rfloor := \max \{k \in \mathbb{Z} \mid k \leq s \cdot \frac{t_{\text{crit}}}{b}\}$.

The situation described above is depicted in Abb. III-4.

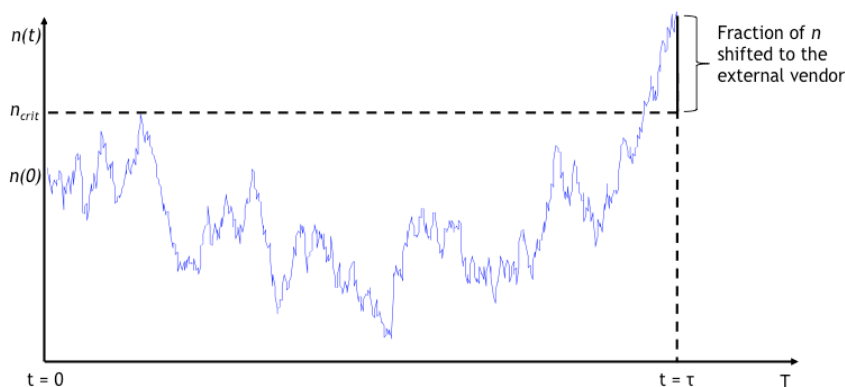


Abb. III-4 Development of the number of service requests in the system over time

After determining the critical number of service requests with respect to the total service time, we present the connection between the number of service requests and the corresponding cash flows for the service provider in the next subsection.

III.3.8.3 Cash Flows for Processing Service Requests

In case the service provider processes the service requests internally, cash outflows for each request are induced e.g. by consumed resources which is why they will be referred to as internal cash outflows. Those cash outflows are also referred to as “insourcing costs” by Benaroch et al. (2010). For those we assume:

(A7) The internal cash outflows for processing a service request $k_{\text{int}} \in \mathbb{R}_0^+$ are constant, known, and equal for all service requests.

As we mentioned earlier, exceeding the critical service time causes unsatisfied customers. Unsatisfied customers become more likely to switch their service provider, which lowers their customer lifetime value and thus can be treated as cash outflows (see e.g. Braunwarth and Ullrich (2010) or Braunwarth et al. (2010)). A more concrete guidance on how to assess respective parameters can be found in section 4. Since a single customer induces one service request, we assume for the corresponding cash outflows:

(A8) The cash outflows resulting from customer dissatisfaction $k_{\text{dis}} \in \mathbb{R}^+$, are constant, known and equal for each of the $(n(t) - n_{\text{crit}})$ -service request that appear in the case $n(t) > n_{\text{crit}}$.

If the service provider chooses to embed an external service provider to support the processing of service requests, further cash outflows have to be considered. In our model we assume that the external vendor offers to process $n_{\text{ext}}(\tau) \in \mathbb{N}_0$ service requests whereby the total number of service requests to be processed externally can be chosen freely at a future point in time $\tau \in \mathbb{R}^+$. For the external processing cash outflows we thereby assume:

(A9) The external cash outflows for processing a service request $k_{\text{ext}} \in \mathbb{R}_0^+$ are constant, known, and equal for all externally processed cash outflows.

Further, the integration of the external vendor induces two investments. Firstly, the initial investment into SOA that provides the standardized interfaces and thus enables the integration of the external vendor has to be made. Secondly, there are cash outflows related to the actual shift of service requests to the service vendor at the time τ . These cash outflows include factors independent of n_{ext} e.g. cash outflows related to changed responsibilities and handovers. These latter cash outflows materialize only if the service provider decides to route services requests to the service vendor at the time τ , whereas the former investment has to be made upfront.

(A10) The cash outflows for the initial investment $K_0 \in \mathbb{R}_0^+$ and the final investment $K_\tau \in \mathbb{R}_0^+$ are constant and known.

III.3.8.4 Valuation of the Option to Embed an External Vendor

In this subsection we want to financially determine the value of the service provider's volume flexibility, or in other words the value of the real option to outsource service requests to an external vendor. In order to determine the business value we have to consider the total cash outflows of the service provider with and without the external vendor at first, respectively denoted as B_0 and $B_{n_{ext}}$. Then we derive the threshold number of service requests at which the service provider is indifferent between the internal or external processing of service requests. Finally we will derive the value of the real option to outsource a certain number of service requests to an external vendor in a future point of time using the real option approach.

Processing all $n(t)$ service requests internally causes cash outflows, of

$$B_0(t) = n(t) \cdot k_{int} + \max((n(t) - n_{crit}) \cdot k_{dis}, 0) \quad (4)$$

If the provider decides to process n_{ext} service requests externally, the total cash outflows for the service provider are given by

$$B_{n_{ext}}(t) = (n(t) - n_{ext}(t)) \cdot k_{int} + n_{ext}(t) \cdot k_{ext} + \max((n(t) - n_{crit} - n_{ext}(t)) \cdot k_{dis}, 0) + K_\tau \quad (5)$$

A necessary condition for outsourcing at time t to result in a positive cash flow is

$$B_0(t) - B_{n_{ext}}(t) > 0 \quad (6)$$

In order to determine the business value of this additional flexibility we further need to determine the number of service requests that will be outsourced. Whereas Benaroch et al. (2010) assume that all service requests are outsourced, we rather flexibly determine this number according to the amount of services in the system at time t . Therefore, we consider the case that all service requests that would have a total service time larger than t_{crit} will be outsourced, i.e.

$$n_{ext}(t) = n(t) - n_{crit} \quad (7)$$

The internal cash outflows from above then become

$$\hat{B}_0(t) = n(t) \cdot k_{int} + (n(t) - n_{crit}) \cdot k_{dis} \quad (8)$$

whereas the external cash outflows are

$$\hat{B}_{n_{ext}}(t) = n_{crit} \cdot k_{int} + (n(t) - n_{crit}) \cdot k_{ext} + K_\tau \quad (9)$$

Now that we know the internal and external cash outflows we can determine the number of service requests $n_{bound} \in \mathbb{N}$ at which the service provider is indifferent between internal or external processing. This number follows from the condition

$$0 = \hat{B}_0 - \hat{B}_{n_{ext}} = (k_{int} + k_{dis} - k_{ext}) \cdot n_{bound} - (k_{int} + k_{dis} - k_{ext}) \cdot n_{crit} - K_\tau \quad (10)$$

and is given by

$$n_{bound} = \frac{(k_{int} + k_{dis} - k_{ext}) \cdot n_{crit} + K_\tau}{(k_{int} + k_{dis} - k_{ext})} \quad (11)$$

Applying the real option approach, we become able to deal with the randomness of $n(\tau)$ at a future time τ . First of all, we see that there is a direct connection between the evolvement of the number of service requests in the service providers' system and the development of the cash outflow. We call this underlying $S(t)$. Due to the random development over time, we only know the value of the underlying at $t = 0$:

$$S := S(0) = (k_{int} + k_{dis} - k_{ext}) \cdot n(0) \quad (12)$$

Outsourcing n_{ext} service requests also generates fixed cash outflows, which do not depend on the underlying. These fixed cash outflows are the execution value of the option and given by

$$X := (k_{int} + k_{dis} - k_{ext}) \cdot n_{crit} + K_\tau \quad (13)$$

Since we are looking for a closed form solution, we need an approximation for our superposed Poisson process with zero drift. Similar to the Black and Scholes model, which assumes that the underlying evolves according to a Geometric Brownian motion, it is possible to find a basic differential equation for the Poisson process whose solution gives the value for the considered option (see Cox and Ross 1975; 1976). But for an underlying Poisson processes it is often not possible to find an analytic solution for the partial differential equation, as it is possible for the Black and Scholes (1973) differential equation, i.e. the famous Black and Scholes formula.

If the intensity of the Poisson process, i.e. the arrival rate of the service requests, tends to ∞ , the Poisson differential equation converges to the Black and Scholes differential equation (Cox and Ross 1975). But already with a finite arrival rate it is possible to approximate the solution of our option with the standard Black and Scholes model (Black and Scholes 1973). Therefore, assuming the discount rate r and the standard deviation σ , the value of the option to embed an external vendor can be expressed by the following equation:

$$\begin{aligned}
C(S, \tau) &= e^{-r\tau} \mathbb{E}(\max(S - X, 0)) \\
&= e^{-r\tau} \mathbb{E}(\max(n(t)(k_{\text{int}} + k_{\text{dis}} - k_{\text{ext}}) - (k_{\text{int}} + k_{\text{dis}} - k_{\text{ext}}) \cdot n_{\text{crit}} - K_{\tau}, 0)) \\
&= (k_{\text{int}} + k_{\text{dis}} - k_{\text{ext}}) \left(n(0) \mathcal{N}(u_1) \right. \\
&\quad \left. - \left(n_{\text{crit}} + \frac{K_{\tau}}{(k_{\text{int}} + k_{\text{dis}} - k_{\text{ext}})} \right) e^{-r\tau} \mathcal{N}(u_2) \right), \tag{14}
\end{aligned}$$

where $u_1 = \frac{\ln\left(\frac{n(0)}{n_{\text{bound}}}\right) + \left(r + \frac{\sigma^2}{2}\right) \cdot \tau}{\sigma \sqrt{\tau}}$, $u_2 = u_1 - \sigma \sqrt{\tau}$ and the standard normal distribution $\mathcal{N}(u) = \int_{-\infty}^u e^{-\frac{1}{2}t^2} dt$.

Finally, we need a decision rule, whether the service provider should invest into the creation of volume flexibility through the integration of an external vendor or not. Therefore, the business value of volume flexibility has to be compared to the initial investments costs, K_0 .

$$V(S, \tau) := C(S, \tau) - K_0 \tag{15}$$

So if $V(S, \tau) > 0$ the service provider should invest into the SOA components and therefore create the flexibility to temporarily integrate an external vendor. Otherwise, if $V(S, \tau) \leq 0$, the investment into the SOA components should not be made. For the case that $V(S, \tau) = 0$ the service provider is indifferent whether to integrate the service provider or not. But we have to note that this value is determined in a conservative way, since we only consider a single point of time where we allow for a shift of service requests to the external vendor. We thereby neglect any future shifts of service requests to the external vendor, which will be cheaper due to already implemented SOA.

III.3.9 Volume Flexibility at a Car-Insurance Company

III.3.9.1 Introduction

In order to evaluate the model described above, we apply it to a real world example in this section. We consider a major German car-insurance company that processes service requests in form of own damage claims. The real world case that underpins the relevance of the problem has already been used by Braunwarth and Ullrich (2010) for the selection of alternate execution paths within the insurance company. The insurance company has a fixed capacity, i.e. a fixed number of employees and machines that process the damage claims. It observes randomly appearing peak demand situations that are caused by randomly arriving damage claims. These demand peaks lead to high total service times and therefore to unsatisfied customers. Thus the risk of losing customers to competitors increases, which lowers their customer lifetime value and therefore the overall customer equity. Consequently, avoiding these complaints becomes an important issue for the insurance company. To cope with this problem, the company evaluates the option to integrate an external vendor. The external vendor would provide the necessary volume flexibility to deal with the uncertain demand through providing additional capacity. The insurance company therefore expects a decrease of the total service times in peak situations and thus aims to avoid the negative effects on the customers through the integration of the external vendor.

The companies' usual claim handling process is assumed to consist of the following activities. First, the damage is scanned and classified, after which the necessary data for the claim is extracted so that the invoice can be checked in the next step. After the check, payment needs to be fulfilled before the claim can be closed. Most of the activities are handled completely automatically or with little binding of employees, except "*check invoice*" which is processed manual. The employees assigned to this process activity handle the claims in sequence, thus it is prone to waiting queues. Due to the human involvement, "*check invoice*" represents a bottleneck of the process and requires a lot of flexibility in particular.

III.3.9.2 Determining the Business Value of Volume Flexibility

In the considered scenario, the company's internal capacity for "*check invoice*" has already been adjusted with respect to the historical average claim arrival rate in non-peak demand situations, i.e. for the regular business. Expressed in full time employees there are $s = 30$ employees planned for this process step. Further, the pure processing (without waiting time in

a queue) of one instance of “*check invoice*” takes usually $T_s(1) = b = 0,5h$ and causes an internal cash outflow of $k_{\text{int}} = 50 \text{ €}$. Since the other process activities are highly automated, waiting queues are less likely to occur at other steps of the processes, so that every arriving service request can be processed immediately prior to the “*check invoice*” step. Nevertheless, the processing time of those activities may take a considerable amount of (fixed) time until completion, e.g. the time until the fulfilment of a transaction from account to account or the time until a letter with legal documents is received. Within the car insurance company, the processing time of the other process activities amount to 5 working days.

An analysis of the company’s data on complaints shows that customers tend to complain if their request is not fulfilled within ten working days, such that the critical total service time with respect to the whole process should not exceed these ten days. Combining this information with the accumulated cycle time of 5 working days for the other process activities, the critical service time of “*check invoice*” is 5 working days, i.e. $t_{\text{crit}} = 40 h$, whereas the companies’ employees work $8 h$ a day. We omit weekends, free days, and effects resulting from arriving claims at these days and assume 240 working days per year. Since the critical process activity is “*check invoice*” due to its bottleneck position in the whole service process, this process step determines the maximal number of possible claims in the system, which the company is able to handle without complaining customers. Thus by equation (3), the insurance company can handle a maximum of $n_{\text{crit}} = 2,400$ claims in the system without complaining customers.

If customers become dissatisfied they might want to switch their car insurance. Especially in times of emerging online direct car insurances, which often advertise their quick response time and pronounce that as their competitive advantage, customer loyalty is hard to obtain. With every customer lost his or her customer lifetime value diminishes, which lowers the overall customer equity. Therefore, the cash outflows resulting from the loss of unsatisfied customers can be analyzed by means the historical average of customers who left the company after they complained. This average value is then homogeneously distributed over all complaints in form of a risk value. Through this procedure the company determined an average loss of $k_{\text{dis}} = 250\text{€}$ for each customer whose total service time is too long.

The company has chosen an external vendor who offers to handle the “*check invoice*” for $k_{\text{ext}} = 75\text{€}$ per claim and additionally causes fixed transaction costs of $K_\tau = 5,000\text{€}$ independently of the number of shifted requests, if the claims are transferred to the vendor at some point in the future. Further the company has to invest $K_0 = 30,000\text{€}$ to implement the necessary SOA

components into the IS infrastructure. Since the insurance company has already moved toward a SOA integration, the initial amount of the investment is moderate. If the company decides to invest into the SOA components, managers agreed that the shift of damage claims could be realized one year later ($\tau = 1$).

Taking into account that the company currently has $n(0) = 2,000$ claims in the system, the risk of exceeding the critical amount of $n_{\text{crit}} = 2,400$ claims becomes highly relevant. Therefore the integration of the considered external vendor seems to be attractive. By analyzing the number of arriving claims on a daily basis collected over the last year, the volatility of the arriving claims can be derived by the standard deviation and in this case amounts to $\sigma = 0.4$. The discount rate used for the valuation is $r = 0.1$ and was derived by determining the average cost of capital.

After we collected all necessary data, we are able to calculate the value of the option contract with the external vendor. By utilizing equation (15) we derive the following result:

$$\begin{aligned} V(S, \tau) &= C(S, \tau) - K_0 \\ &= V(450,000\text{€}, 1) = C(450,000\text{€}, 1) - 30,000\text{€} \\ &= 55,106\text{€} - 30,000\text{€} = 25,106\text{€}. \end{aligned} \tag{16}$$

Hence, the car insurance company should invest into the SOA components.

III.3.9.3 Interpretation and Discussion

As the result of the application of our model we conclude that – given the information described above – the service provider should conduct the technical integration of the external vendor due to the positive business value of the resulting volume flexibility. However, if one has to make this decision, it is necessary to be aware of the robustness of this result.

Therefore, we first need to discuss ROA as valuation method in greater detail. As Ullrich (2013) revealed, there are four key assumptions that have to be fulfilled in order to be able to apply option pricing models to the valuation of IS investments. The most critical assumption is that the underlying of the option needs to be traded to allow for a risk neutral valuation. Ullrich (2013) suggests to use a preference-related valuation approach in order to avoid this assumption. Our underlying of the option, i.e. the difference between internal and external costs multiplied by the number of service requests, may be tradable, if one assumes that there are

enough specialized and publicly listed service vendors that can process any number of service requests at different prices. Furthermore, we follow the argumentation of Taudes et al. (2000), who state that the value of the real option does not need to be accurate; it can rather be interpreted as a lower bound. In our case, the value obtained above can also be interpreted as a conservative valuation, since we neglect the possibility of repeating shifts of service requests to the external vendor. If the service provider chooses to shift its service requests to the external vendor a second time, no initial investments would be necessary anymore, which makes that step even more profitable.

Through the application of SOA – especially the Black Scholes Model – the robustness of our result can be easily analyzed through partial differentiation of the different input parameters (also known as Greeks). This is especially helpful to check the effects of input parameters that are difficult to estimate in advance on the result. In our case it is interesting to analyze how the volatility, which could be derived from historical data in the real-world example, affects the result. Abb. III-5 therefore shows the business value of the investment depending on the value of the volatility used for the calculations. As it can be seen in Abb. III-5, the investment would be denied if the volatility falls below 26%. However, since historical data showed a volatility of 40% and no signs of lower volatility were observable, the result seems to be robust with respect to the volatility.

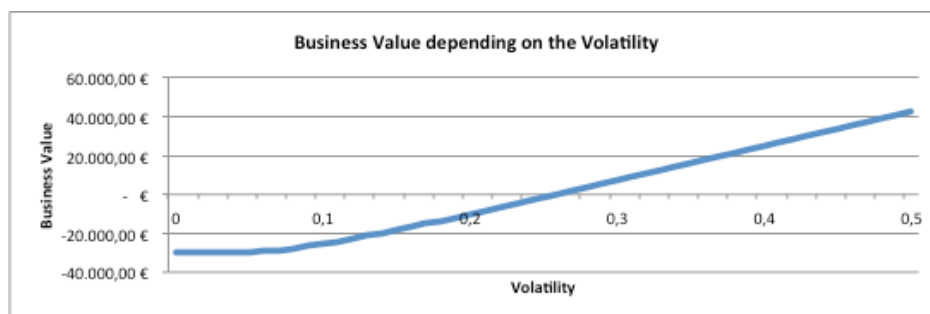


Abb. III-5 Business Value of the investment depending on the volatility

III.3.10 Conclusion

In this paper, we presented an analytical model that determines the business value of flexibility resulting from an IS-based integration of an external vendor. Thereby we considered the trade-off between the investments into the technical requirements (e.g. SOA) that are necessary to gain volume flexibility and the negative effects of unsatisfied customers on the customer equity. Our model is based on the real options approach, which is an appropriate framework for our

model, since it is able to value the core element of flexibility: the ability to respond to uncertain events in future. We demonstrated the applicability of our model by valuing an investment decision of a German car-insurance company.

With our model, we contribute to IS literature by providing the (to the best of our knowledge) first analytical model which provides a closed form solution for the value of a future IS-based integration of an external service vendor considering important economic parameters such as contracting costs and indirect effects on the customer equity. Furthermore, we extend the new research stream initiated by Benaroch et al. (2010) that applies ROA to the valuation of additional capacity. To this end, our model reveals that the consideration of the indirect economic effects can be a game changer when deciding whether to perform service requests in a company or to shift them to an external vendor.

However, the model is beset with the following limitations, which should be (and already are) subject to further research:

- Currently, we focus on shifting the demand peak to an external vendor only once at a specific future point of time. This is a pessimistic valuation of the respective IS investment, since for further shifts of demand peaks no additional investments into the technical infrastructure are necessary. Therefore, future research should consider multiple periods and therefore multiple possibilities to shift demand peaks to an external vendor.
- Although we consider negative effects on customer equity by analyzing total service time and time preferences of customers, our model is only a first step towards a thorough understanding of the interplay between customer preferences and flexibility achieved through IS investments such as e.g. SOA components. Due to that we treat each customer's reaction the same, even independent of the actual total service time. Future research should analyze those effects on a more detailed level, such as (e.g. exponentially) increasing negative effects depending on the total service time.
- Our paper explicitly addresses the cash effects of capacity shifting to external partners. We consider this focus as an important part, but we are aware that there might come other, more qualitative aspects into play. These include for example a possible loss of quality for the shifted service requests, risk and monitoring issues or strategic considerations not to shift capacity if the related output concerns key activities of a company and therefore should remain internal. A combination of respective research (especially from outsourcing

literature) and quantitative models such as ours would allow for a more holistic decision support.

Nevertheless, the additional insights resulting from the extensions mentioned above need to outweigh the increased complexity of the model and the possible loss of deriving a closed form solution. Therefore, the extensions should be considered carefully. Despite its shortcomings, our model enables a company to determine the business value of IS leading to the creation of volume flexibility. We hope that our paper provides fellow researchers with a sensible foundation for continuing research in the domain of business value of IS and flexibility valuation.

III.4 Beitrag 5: „Valuation of Manual and Automated Process Redesign from a Business Perspective“

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Zusammenfassung:

Purpose *The continuous redesign of processes is crucial for companies in times of tough competition and fast-changing surrounding conditions. Since the manual redesign of processes is a time- and resource-consuming task, automated redesign will increasingly become a useful alternative. Hence, future redesign projects need to be valuated based on both a manual and an automated redesign approach.*

Design/methodology/approach *In this paper, we compare the manual and automated process redesign on the basis of the Business Process Management (BPM) lifecycle. The results form the basis for a mathematical model that outlines the general economic characteristics of process redesign as well as for the manual and automated approaches. Subsequently, we exemplarily apply our model to a set of empirical data with respective assumptions on particular aspects of the automated approach.*

Findings *In the problem setting described in the paper, our valuation model shows that automated process redesign induces an equal or higher number of optimized processes in a company. Therefore, we present a decision support that outlines how much to invest in automated process redesign.*

Research limitations/implications *Our model considers the cost side of automated process redesign; therefore, further research should be conducted to analyze the possibility of higher returns induced by automated redesign (e.g., through a quicker adaptation to real-world changes). Moreover, for automated redesign, there is no requirement for broad empirical data that should be collected and analyzed as soon as this approach leaves the basic research and prototyping stages.*

Practical implications *This paper presents an approach that can be used by companies to estimate the upper limit for investments in manual and automated process redesign. Working under certain general assumptions and independently from actual cost and return values, we demonstrate that automated process redesign induces an equal or higher ratio of optimized processes. Thus, companies introducing automated redesign can not only apply the model to evaluate their investments but can also expect a higher ratio of optimized processes for this approach.*

Originality/value *As existing literature primarily focuses on the technical aspects of automated process redesign, our findings contribute to the current body of literature. This paper discusses a first decision-support for the economic aspects of automated process redesign, particularly with regard to the investments that are required for it. This information is relevant as soon as the approach leaves the stage of a prototype.*

III.4.1 Introduction

Business process management (BPM) has become a powerful instrument for fighting a company's lack of capability to adapt to changing customer needs, legal requirements, and other surrounding conditions, and is thereby essential for a company's organizational design (e.g., Buhl et al. (2011), Gartner (2010), Sidorova and Isik (2010), Trkman (2010), vom Brocke et al. (2011)). Although BPM has supported the redesign of business processes since the early 1990s, there is scope for improvement, especially in association with modern IT systems, which are considered critical success factors in business process reengineering (Ahmad et al. 2007).

This lack of automation can be observed in typical redesign projects. The redesign is usually performed by analysts and managers who have in-depth knowledge in their respective domains. Due to its high human involvement, we call this approach *manual process redesign*. Because of the increasing complexity of today's processes, manual process redesign is very time and resource consuming. Thus, processes are redesigned rarely, with high expenses, or not at all.

This results in an increased time to market and high costs resulting from suboptimal processes. To deal with these shortcomings, researchers have sought alternatives to manual redesign. Recent research elaborates on how process redesign can be automated and supported by IT. New approaches addressing this issue (e.g., Betz et al. (2006), Brockmans et al. (2006), Hepp and Dumitri (2007) and Heinrich et al. (2008)) are situated in the field of semantic business process management (SBPM) and are based on the vision of Hepp et al. (2005). Among other aspects, SBPM includes the semantic annotation of process actions as components of a business process in order to enable semantic-based reasoning for the automated creation, adaptation, and redesign of business processes. We call this approach *automated process redesign*. Due to high automation, automated redesign can offer a faster and cheaper development of process models than its manual counterpart. However, the semantic annotation of process actions as well as the technical integration of the related planning software in a company's IT architecture can result in high expenses.

This trade-off between high setup costs and improvements in the redesign approach leads to the following question: Under which economic circumstances are extensive investments in automated process planning justified? The need for an answer to this question is reinforced by the fact that research in the field of automated process redesign has advanced and the first applications that are a result of these advances are becoming more feasible. For example, process verification, a method closely related to automated process modeling, "has matured to a level where it can be used in practice." (Wynn et al. 2009).

We, therefore, present a quantitative model that derives an upper limit for investments in automated process planning and show that it is superior to manual process planning. As a necessary base for this decision, we evaluate the basic characteristics of process redesign projects (PRPs) and also study the factors that influence the optimal selection of these projects.

Consequently, we put forth the following research questions:

- (1) Which and how many process redesign projects should be realized based on their respective costs, returns, and project sizes?
- (2) What is the upper limit for investments in automated redesign so that it is superior to manual redesign from a business perspective?

As already mentioned, the answer to the first research question forms the basis for the second one, since the optimal selection of PRPs gives different results for each approach. This selection

is represented in our objective functions, which are the contribution margin functions of the two alternatives. The functions are subject to the execution of redesign projects, specifically to their exogenously given return and cost parameters, as well as to given redesign project sizes. Our decision variable is a ratio of the processes to be redesigned that influences the attainable yield. After making an optimal selection of PRPs that will lead to an achievable monetary contribution margin, we compare the utility (represented by the yield) of both manual and automated redesign to identify an upper limit for investments in automated redesign.

We are aware that the semantic annotation necessary for automated process redesign opens up further opportunities for higher returns for companies that invest in process management. Nevertheless, in this paper, we focus on the cost side of process redesign, since the possible cost reduction of automated process redesign should encourage companies to adopt an automated redesign approach. Moreover, the return on investment in the short run would be the main evaluation criterion for a company. Therefore, this contribution serves as the first step for companies to improve their process redesign approach or change it to a more adequate one as soon as the automated process redesign leaves the stage of prototyping.

In chapter III.4.2, we elaborate on the literature. In chapter 3, we state the general characteristics of process redesign, introduce automated process redesign, and compare this approach with its manual counterpart. Based on these findings, we present an optimization model in chapter III.4.4. In chapter III.4.5, we illustrate the practical applications of the model on the basis of empirical data on a large German financial services provider. In the last chapter, we summarize the results and point out areas for future research.

III.4.2 Related work

The redesign of business processes is based on the presence of flexible processes and the flexible creation of process models. Process flexibility can be classified according to three criteria: the abstraction level of change (Where does change occur?), the subject of change (What has changed?), and the properties of change (How are things changing?) (Regev et al. 2005). The field of automated process redesign is related to the enhancement of flexibility in business processes. The flexible creation of process models according to real-world changes helps to rapidly identify the subject of change. In particular, the executed activities and the related preconditions for these can be identified and documented quickly by comparing the process models before and after the real-world change. However, in our paper, we do not focus

on the process flexibility resulting from automated redesign. We concentrate on the economic aspect of process redesign and show the differences between automated and manual process redesign.

The need for the flexible creation and adoption of process models typically represents a bottleneck for numerous companies (Becker and Kahn 2003; van der Aalst et al. 2006). The high human involvement which necessitates greater effort during manual process redesign is exemplified by Harrington (1991), who suggests that the manager or process expert who is in charge of the process redesign should be physically present in the division in which the business process to be redesigned is situated, and observe the procedures in detail.

New approaches toward process modeling, such as those detailed by Betz et al. (2006), Brockmans et al. (2006), and Hepp (2007), are employed in the field of SBPM and are based on the vision of Hepp et al. (2005). Heinrich et al. (2008) and Eisenbarth et al. (2011) specifically propose a semantic approach that uses ontologies as the basis of an algorithm for automated process redesign.

Current research does not consider the economic aspects of SBPM. However, a fundamental analysis is claimed several times (Haniewicz et al. 2008; Hepp 2007). Thus, the need for a valuation model for automated redesign arises as soon as the research leaves the theoretical state and advances to prototypes, since the creation of ontologies and the semantic annotation of process actions involve, among others, high implementation costs (Heinrich et al. 2008; Kuropka and Weske 2008).

The field of automated process redesign is closely related to the field of automated web service composition. Héam et al. (2007) present an approach to semantically specify different types of service costs for a web service, such as monetary costs and execution time. This annotation is an aspect of service quality and is further used to economically facilitate the automated composition of web services. In contrast, we take the costs of PRPs as given. Additionally, we outline a model that provides details on how to use these costs and predicted returns, and select PRPs that are economically feasible. Finally, we present a key figure that supports the decision for a proper redesign approach.

ONTOCOM, the cost model for ontology engineering, was presented by Simperl et al. (2006). ONTOCOM predicts the costs arising from the creation of an ontology that follows a particular ontology development strategy. Analogous to COCOMO (constructive cost model) (Boehm

1981), ONTOCOM features a variety of cost drivers that influence the costs related to the activities that helped create the ontologies. Although ONTOCOM could help estimate the cost of an ontology - and this ontology is required for automated process redesign - our paper does not focus on the creation of ontologies.

When creating ontologies, other factors besides the economic aspect need to be considered. Hepp (2007) points out four obstacles to the use of semantic concepts such as ontologies: conceptual dynamics (new elements arise while other elements become irrelevant), economic incentives (the creation and use of the semantic concepts have to be economically reasonable), ontology perspicuity (the ontology should be interpretable by its users), and intellectual property rights (since industrial standards are often protected by intellectual property rights, legal agreements with the owners of ontologized industrial standards are necessary). These four obstacles can be examined from the perspective of automated process redesign. The main part of our paper is dedicated to detailing the economic advantages of using the automated redesign approach. The perspicuity of the automatically generated process models is adequate, since the resulting process models are represented in acknowledged modeling languages such as UML-activity diagrams. Issues regarding intellectual property rights are dealt with by the payment of a certain acquisition price, which we attribute to automated process redesign software and the associated ontologies. The obstacles of conceptual dynamics, however, are real-world changes and are not directly addressed in our paper. This will, however, be subject to further research.

III.4.3 Characteristics of process redesign

To adapt, for example, to changing customer needs or legal requirements, multiple processes need to be redesigned from time to time. Usually, this is accomplished by PRPs. Each PRP can be conducted only once, is targeted at redesigning an existing business process, and features a certain project size. Furthermore, we assume that a PRP can only be conducted completely or not at all. For simplicity, we focus on redesigning already documented and modeled processes in this paper. However, the model may be adapted to include the modeling of new processes in future research. We state the general characteristics of automated process redesign in subsection III.4.3.1 and compare this approach with manual redesign in subsection III.4.3.2.

III.4.3.1 Automated process redesign

Automated process redesign is a relatively new way of redesigning processes. It is based on the semantic definition of the possible process steps (actions) that are automatically arranged in a control flow, and lead from an initial state to the desired final state. The redesign is no longer performed by human beings, but by an algorithm that uses semantic concepts and automated reasoning to create process models, which eventually have to be controlled by experts.

Some approaches in SBPM suggest a comprehensive conceptualization of all the model and meta-model elements of the process model in order to include a wide range of goals, such as a test for the correctness of models (Thomas & Fellmann 2007). Others choose a less restrictive approach for the annotation of process actions, which is similar to the semantic annotation of semantic web service composition, and aims specifically at the redesign of business processes (Heinrich et al. 2008).

Before automated redesign can be used, certain requirements have to be fulfilled. First, the redesign software (e.g., the SEMPA tool, cf. Heinrich et al. (2008)) is to be purchased and installed in the IT system of the company. The next step for the company is to analyze its environment, that is, to identify all relevant concepts that need to be annotated semantically (e.g., a customer's financial data), their relationships, and the necessary process actions. The identified concepts in the specific domain of interest as well as their relationship have to be represented in an ontology. This ontology either has to be created from scratch or can be an existing (public) ontology (e.g., the COBrA ontology proposed by Pedrinaci et al. (2008)). Using a public ontology involves costs for search, application, analysis, and customization. For a deeper analysis of the costs of ontology engineering, refer to Simperl et al. (2006). The previously identified process actions have to be semantically annotated by their input and output parameters (by means of ontological concepts) and filed into a process library, a repository of the redesign software that contains the process actions used during automated modeling. It must be noted that we consider the expressiveness of the semantic annotation as fixed; that is, we do not distinguish between different forms of semantic annotations.

As soon as the requirements for the automated process redesign are given, the planning problems for each process redesign have to be defined before planning can begin. A planning problem consists of initial and final states. The initial state represents the starting point of a process, whereas the goals represent the desired results of it. The outcome includes the graphical

representation of the redesigned process as a process model, which is comparable to that in manual process redesign.

III.4.3.2 Comparison of manual and automated process redesign

According to Karastoyanova et al. (2008, p.1728), the SBPM lifecycle includes the *modeling*, *analysis*, *configuration*, and *execution* phases. Process redesign includes the *analysis* and *modeling* phases, while *configuration* and *execution* are directly affected by the output of the redesign, that is, the redesigned process models.

The *setup* establishes the necessary base for the application of the redesign approach, and needs to be executed only once. The initial steps, such as acquiring the required software and hardware for redesign, training the redesign personnel, and purchasing licenses, are to be completed. Manual process redesign requires investments in the department charged with the redesign, as well as expenses for nonautomated modeling tools. For automated redesign, the *setup* is much more complex. As mentioned previously, the actual automated redesign software has to be acquired, an ontology with a general base of multiple purpose concepts likely to be present in a large number of processes has to be created or customized, and the process library has to be established.

In *analysis*, the potential for redesign is explored. Specific processes concerning modified conditions, such as new legal requirements, a changed business model, novel customer needs, and technological innovations, are analyzed. With a manual approach, *analysis* includes activities to be completed by managers or process experts, such as understanding the workflow and the surrounding conditions of the process, defining the desired goals, identifying the specific actions involved in the current process workflow, and determining how these actions are interrelated. The automated approach, on the other hand, does not require an in-depth understanding of the specific workflow of the processes. In either case, it is necessary to identify the current state of processes as well as the desired goals in order to define the planning problems. Additionally, the ontology and the process library are extended with further concepts and necessary actions.

Modeling refers to the actual revision of processes; that is, the processes are adjusted based on the need for change, which is determined in the analysis phase. The best fitting process steps are selected, the appropriate organizational sections are specified, and finally, the control flow is arranged with the aid of control flow structures. The process steps may be selected on the

basis of speed, quality of service, cost (Hammer and Champy 1995), the financial aspects on the operational level (vom Brocke et al. 2010), or the process value (Bolsinger et al. 2011). The results are graphically represented in process models such as UML-activity diagrams (OMG 2008) and Event Driven Process Chains (Keller et al. 1992). For manual redesign, the modeling is performed by human beings who reassess the workflow of the process. The process expert has to answer questions such as “Which actions can be realized in parallel?” “Which dependencies exist between multiple process actions?” and “Which possible orders of process actions lead to the desired final states?”. Automated redesign also involves these tasks, but unlike manual redesign, they are performed automatically. In the modeling phase of automated process redesign, human interaction is required only for the input of the previously defined initial and final states, and for a revision of the generated process models.

The effects of process redesign can be identified during the last two phases of the SBPM lifecycle. The completed process models are rolled out during the *configuration* phase. More precisely, concrete resources are assigned to the corresponding process steps and the process models are operationalized and implemented. The necessary changes in the company’s organizational structure and IT infrastructure are also made. If all preceding phases have been successfully executed, the redesigned processes can proceed to the *execution* phase. During this phase, the processes can be executed as planned, and they generate cash flows over multiple executions. Both redesign methods result in qualitatively equal process models, which have to be operationalized and implemented in the same way. As a result, the execution of the redesigned processes is analogous. Automated process redesign has more advantages, such as the representation of the various feasible solutions to the problem, and the possibility of the usage of semantic annotations for controlling the process. However, in this paper, we concentrate on the cost side of this approach, leaving the exploration of its other advantages to future research.

To sum up, we can state that in the *setup* phase automated redesign causes much higher setup costs due to the high cost of software, ontologies, and process libraries. The setup costs for manual process redesign are the expenses for training personnel on process modeling and the license costs for nonautomated process modeling tools. We can conclude that automated process redesign involves lower costs for the redesign of one process than manual process redesign, especially considering the amount saved due to automatization in the phases of *analysis* and *modeling*.

III.4.4 Model

From an economic point of view, investments in process redesign should only be made if the resulting contribution margin of the redesign exceeds these investments. Thus, the contribution margin of the redesign serves as an upper limit for investments in this area. Consequently, the maximum contribution margin of process redesign and thus the optimal number of PRPs have to be determined, since redesigning all possible processes is not considered reasonable from an economic point of view. Therefore, a PRP aims at the redesign of a single process. To provide a mathematical foundation for the selection of PRPs, we introduce the ratio of redesigned processes (RORP) as a continuous variable and then match the selection of PRPs to this measure. To calculate the optimal RORP, we need to evaluate the returns of a PRP (the change in cash flow resulting from the execution of a redesigned process) and compare these values with the respective costs of the PRP (the costs of redesign). We introduce a general optimization model for process redesign in subsection III.4.4.1 and extend this model in subsection III.4.4.2, for a comparison of manual and automated process redesign.

III.4.4.1 Valuation of process redesign

In this subsection, we present our economic model in a general form. The following definitions and assumptions form the basis for the subsequent optimization model. Assumption 1 presents the exogenously given parameters of the model.

Assumption 1: A PRP is characterized by returns (the discounted additional returns from the execution of a PRP), costs (the discounted redesign costs of this process), and size (the project size of the PRP), which are ex ante predictable for a defined forecasting horizon, and thus exogenously given.

The project size (e.g. measured in person days) for a PRP serves as a measure of the complexity of the process redesign. The more complex the redesign, the higher will be the project size.

Definition: The continuous [1] variable to be optimized is the RORP, indicated by x . It is the ratio between the cumulated project size of the PRPs to be conducted and the cumulated project size of all possible PRPs.

A RORP of $x = 0$ implies that no PRP is performed, while $x = 1$ implies that every PRP is accomplished. $x = 0.5$ indicates that 50% of all cumulated project sizes should be spent for the most profitable PRPs.

To determine its “profitability”, we analyze each PRP with respect to its resulting returns, redesign costs, and project size. We then derive the influence of each PRP on the cumulated returns and rank their marginal effect with respect to the project size. In other words, we sort all projects in descending order by the ratio “returns/project size.” Cumulating the sorted returns and costs of each PRP leads to return and cost functions, $R(x)$ and $C(x)$, which represent the returns and costs of all possible PRPs, sorted by descending profitability.

With an increasing x , the previous sorting causes monotonically increasing returns. The increasing form of the function is realistic because a higher number of PRPs lead to higher cumulated returns. Further, a diminishing marginal return is directly associated with the sorting, in descending order, of the ratio “returns/project size” for all PRPs. To simplify calculations, we make the following Assumption 2.

Assumption 2: The cumulative return function $R(x)$ is a positive, continuous function that is continuously differentiable twice, monotonically increasing ($(dR(x)/dx) \geq 0$), and concave ($(d^2R(x)/dx^2) \leq 0$).

The cumulative cost function of process redesign is a strictly monotonically increasing function. Analogous to the returns of the redesigned projects, the redesign costs are cumulated and then sorted according to an increasing RORP. Further, the cost function is linear, since the redesign cost of a PRP is a result of the project size multiplied by a given cost unit rate. The cost unit rate, and thus, the gradient of the cost function, is assumed equal for every PRP.

Assumption 3: The cumulative cost function $C(x)$, is a positive, linear function that is strictly monotonically increasing ($(dC(x)/dx) > 0$), and features setup costs $S \geq 0$. The variable cost function $\hat{C}(x)$ does not include setup costs; that is, $C(x) = \hat{C}(x) + S$.

Abb. III-6 visualizes the general optimization setting.

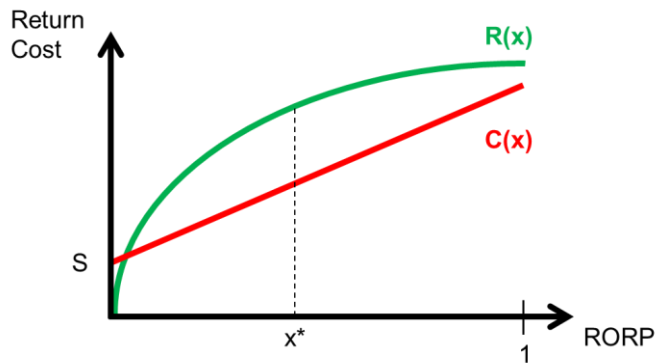


Abb. III-6 General optimization setting

We now consider the variable cost function $\hat{C}(x)$. The contribution margin $\hat{Y}(x)$, is used in the second step of the calculation of the upper limit of the setup costs of process redesign S^{max} .

The contribution margin $\hat{Y}(x)$, depends on the optimal RORP x . It is determined by calculating the difference between the returns $R(x)$ of the completed process redesigns and the variable costs $\hat{C}(x)$ induced by the redesign projects.

$$\hat{Y}(x) = R(x) - \hat{C}(x) \rightarrow \max! \quad (1)$$

The company strives to maximize its contribution margin and seeks to arrive at the optimal RORP to achieve this, which we denote by \hat{x} [2].

To derive the actual optimum x^* in $[0; 1]$, the position of \hat{x} has to be analyzed.

$$\text{For } \hat{x} \in [0; 1]: \quad x^* = \hat{x} \quad (2)$$

$$\text{For } \hat{x} > 1: \quad x^* = 1 \quad (3)$$

$$\text{For } \hat{x} < 0: \quad x^* = 0 \quad (4)$$

Additionally, there is no process redesign to be applied ($x^* = 0$) for a negative contribution margin $\hat{Y}(\hat{x})$. To ensure a positive yield $\hat{Y}(x^*)$, the contribution margin of the redesign projects $\hat{Y}(x^*)$ has to exceed the setup costs S . Therefore, the upper limit for the setup costs is

$$S^{max} = \hat{Y}(x^*). \quad (5)$$

Based on this general optimization, we now compare manual and automated process redesign and derive a decision support on how much to spend for manual or automated process redesign.

III.4.4.2 Comparison of manual and automated process redesign

We determine the suitable cost functions depending on the RORP for both manual and automated redesign. According to Assumption 2, there exists only one return function for both the redesign approaches. In our notation of the model parameters, we use the lower indices of M and A for manual and automated redesign, respectively. As pointed out in subsection III.4.3.2, the variable costs for automated redesign are lower than that for manual redesign. As a result, the cost curve for automated redesign has a lower gradient.

Assumption 4: The cumulative manual and automated cost functions are denoted by $C_M(x)$ and $C_A(x)$. They feature different gradients with $\left(\frac{dC_M(x)}{dx}\right) > \left(\frac{dC_A(x)}{dx}\right) > 0$ and different setup costs $S_A > S_M > 0$.

Both cost functions satisfy Assumption 3. The optimization setting for both approaches is depicted in Abb. III-7.

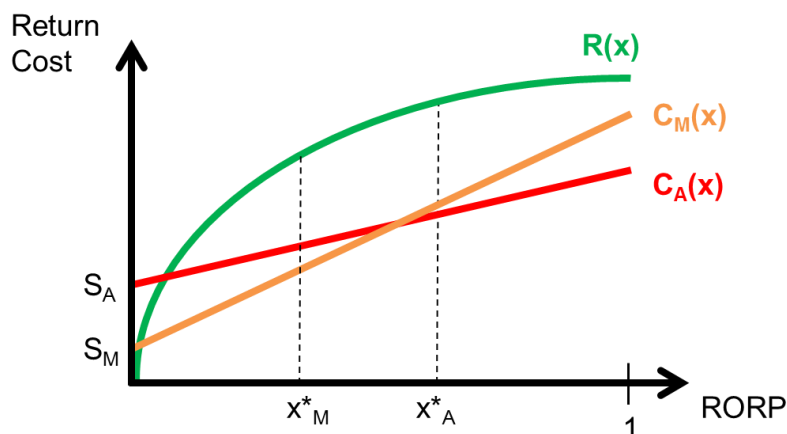


Abb. III-7 Optimization, with consideration of manual and automated cost functions

As described in subsection III.4.4.1, we consider the variable cost functions $\hat{C}_M(x)$ and $\hat{C}_A(x)$ in the first step. Abb. III-7 illustrates that automated process redesign not only induces lower variable costs in a certain RORP, but also enables, in all possible cases, an equal or higher optimal RORP, and thus, an equal or higher contribution margin resulting from the redesign projects. The higher RORP is thereby based on the monotonically increasing shape of the return function $R(x)$, the strictly increasing shape of the cost functions, and the lower gradient of $\hat{C}_A(x)$ ($(\frac{d\hat{C}_A(x)}{dx}) < (\frac{d\hat{C}_M(x)}{dx})$).

$$\hat{Y}_A(x) \geq \hat{Y}_M(x) \quad (6)$$

To decide whether the superior contribution margin of the higher RORP of automated redesign justifies the higher setup costs S_A (subsection III.4.3.2), we have to compare the overall yield $Y_A(x_A^*) = \hat{Y}_A(x_A^*) + S_A$ and $Y_M(x_M^*) = \hat{Y}_M(x_M^*) + S_M$ of both approaches in their respective optimal points x_A^* , x_M^* .

We can state the condition for the application of automated process redesign.

$$Y_A(x_A^*) \stackrel{!}{\geq} Y_M(x_M^*) \quad (7)$$

Thus, the upper limit for the setup costs of automated redesign can be defined as

$$S_A^{max} = \hat{Y}_A(x_A^*) - \hat{Y}_M(x_M^*) + S_M \quad (8)$$

As we can see in (8), the superior contribution margin of automated redesign is opposed to higher setup costs of this approach. Thus, the higher contribution margin for automated redesign, in addition to the setup costs for manual redesign, determines the upper limit for the setup costs of automated redesign.

III.4.5 Exemplary application on empirical data

We analyzed a set of project data from a major German financial service provider for an exemplary application of our model. This involved 18 PRPs from the security business [3]. Therefore, these processes had to be evaluated on the costs and returns for each PRP. Since the analyzed financial service provider uses manual process redesign for its PRPs, the data sets did not contain any specific costs for automated process redesign. Therefore, we had to make respective assumptions on the calculation of these costs. These assumptions are based on first rough estimates of experts in the fields of business and IT, and resulted in the definition of best-, worst- and average-case scenarios.

As stated earlier, in reality, the measurement of the RORP is discrete because of the selection of the PRPs. Thus, our model is applied on the empirical data in a discrete form. In case the gradient of the cost and return function are identical, all projects with higher returns than costs are to be chosen.

The empirical data contained business cases for each of the 18 PRPs. These were calculated for two years (8 quarters), which represents the given forecasting horizon for the following

consideration. A business case is structured as shown in Tab. III-4 **Fehler! Verweisquelle konnte nicht gefunden werden.**

Tab. III-4 Design of a business case

	Analysis & Modeling	Configuration	Execution
returns	-	-	Additional cash flow of redesigned process
costs	Required person days multiplied by cost rate	Costs for the realization of redesigned processes	-

Although the actual values were slightly modified to maintain anonymity, the conclusions remain the same. To make the given data compatible to our model,

- we took the given number of person days for the realization of the redesigned process as a proxy of the project size of a PRP,
- we discounted the redesign costs and the returns of the execution of the redesigned processes with a given rate of interest,
- we only considered returns that could definitely be assigned to process redesign. Thus, we deducted the costs of the configuration phase from the returns of the execution phase to be able to attribute the remaining returns to the analysis and modeling phases.

With these adjustments, we derived the influence of each project on the returns, and ranked all projects based on their marginal effect on the required number of person days. For the comparison of automated and manual process redesign, the interviews mentioned above showed, in a worst-case scenario, that the variable costs of automated redesign should decrease by 30% in comparison to their manual counterpart. In the best case, the variable costs of automated redesign showed a decrease of 70%. We will therefore consider an average case with the variable costs of automated redesign being half of the variable costs of manual redesign. Instead of providing assumed setup costs, we aim to identify a cost limit for the introduction of automated process redesign. Note that in the data sets, the cost rate for a person day for process redesign increases over the period and thus compensates for the discounting of the costs over multiple periods. As a result, the cost function remains linear.

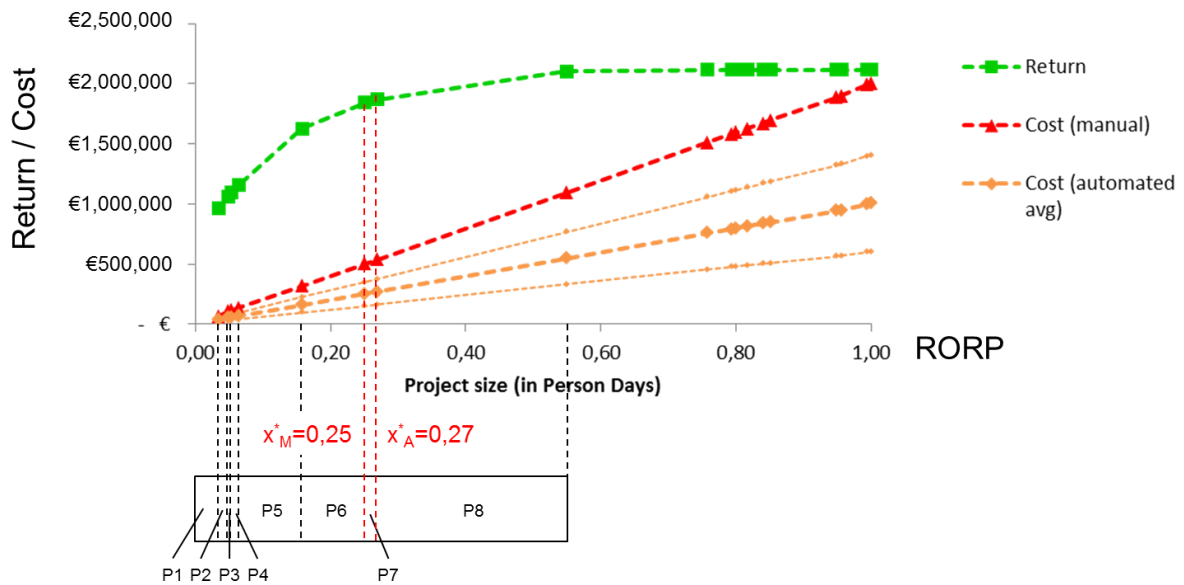


Abb. III-8 Representation of project related values

We can see in Abb. III-8 that for manual process redesign, the optimal RORP is reached at $x_M^* = 0.25$, which indicates that using 25% of the possible person days for process redesign leads to the maximum returns of $R(x_M^*) = €1,843,752$ and redesign costs of

$\hat{C}(x_M^*) = €500,500$. The maximal contribution margin for manual redesign is, therefore, $\hat{Y}_M(x_M^*) = €1,343,252$. We can observe that taking into consideration the ranking of all the projects, launching six projects results in the optimal contribution margin.

The results differ for the average case of automated redesign (lower bold function in Abb. III-8). The optimal RORP is located at $x_A^* = 0.27$, and this includes project P7, which would not have been conducted with manual process redesign. This leads to the maximum returns of $R(x_A^*) = €1,867,274$ and redesign costs of $\hat{C}(x_A^*) = €268,450$. The maximum contribution margin for automated redesign is, therefore, $\hat{Y}_A(x_A^*) = €1,598,824$.

With the application of automated process redesign, the company could generate an additional contribution margin of €255,572 ($= \hat{Y}_A(x_A^*) - \hat{Y}_M(x_M^*)$). This gain (+19%) can be interpreted as the maximum limit for the setup costs for the implementation of automated process redesign, compared to that of manual process redesign.

Although approximately €250,000 does not seem to cover the investment for the automated redesign approach, it must be noted that we only considered 18 data samples. In a real-world company, there is likely to be a much higher number of processes to be redesigned. With an additional contribution margin of 19%, the investment should be covered. Further, until this

point we have only considered the effect of redesigns over a short period. Over a long term, the investment in automated redesign is more likely to be economically advantageous, since the setup costs for automated redesign is likely to be far lower after the initial investment.

III.4.6 Conclusion and outlook

This paper presents an approach that can be used by companies to estimate the upper limit for investments in manual and automated process redesign. The paper outlines the fundamental characteristics of process redesign and presents an optimization model that shows that sorting PRPs in descending order by the ratio “returns/project size” enables an optimal selection of PRPs based on their respective costs, returns, and project sizes (cf. research question (1)). We show that the upper limit for investments in automated redesign results from an equal or higher ratio of optimized processes and thus from an equal or higher contribution margin of the automated approach (cf. research question (2)). We did this by working under certain general assumptions and independently from actual cost and return values. To provide an example for this, we applied our approach to empirical data and showed that the model can be applied to real-world situations and that a higher total contribution margin of process redesign can be achieved by automated process redesign, than by its manual counterpart. Our approach is supposed to help decision makers in the phase of creating business cases by evaluating automated process redesign projects. As we described theoretically as well as in our example, it is possible to realize more PRPs and thus a higher process maturity using automated redesign than with the traditional manual approach. By furthermore considering the advantages gained through reuse of modeled process actions from the first automated PRPs (which have been partially disregarded so far), even more PRPs can be expected to be realized. Therefore, if a company frequently needs to change its processes, automated redesign can be a means to realize a higher maturity throughout the entire process landscape. From a scientific point of view, we offer a first approach to cover the evaluation of automated process redesign projects: This needs to be refined and empirically evaluated in further research. Accordingly, it must be acknowledged that we considered only 18 data sets in our example, and hence, we cannot derive statements regarding the whole process landscape of a company. We have concentrated on the financial advantages of process redesign. Therefore, further exploration is necessary whether the semantic annotation of running processes offers any further advantages and what these advantages are. One advantage could be a higher flexibility of processes resulting from a faster adaption to real-world changes. However, we do not analyze this aspect in this paper. Further,

analyses of the criteria for choosing automated redesign (e.g., execution, update frequency of processes) are possible avenues for future research. There are several unanswered questions, since there are no examples of completely functional automated process redesigns in a real-world company. Thus, the quality of automatically created process models as well as the handling and usability of the redesign software is still unclear. Moreover, the actual costs of automated redesign have not been confirmed, and it is therefore possible that the automated creation of process models is, by now, more expensive than expected. However, under economic considerations, we have demonstrated that automated process redesign, when applied to real-world companies, can be a promising approach in the field of (semantic) business process redesign.

III.4.7 Notes

[1] In reality, the measurement of a RORP will most likely be discrete since PRPs can only be conducted completely or not at all. Therefore, we consider the RORP to be discrete for the theoretical foundation in this chapter. In the application of the model to a real-world situation (chapter III.4.5), we demonstrate how to select the appropriate PRPs according to the optimal RORP.

[2] With the given functions and assumptions, it is theoretically possible that the second-order condition is not satisfied for all \hat{x} satisfying the first-order condition (as $R(x)$ is not strictly concave), and thus, there is no unique \hat{x} . This would lead to an indifference between all \hat{x} with $(dR(x)/dx) = (d\hat{C}(x)/dx)$. We neglect this special case for the following model to analyze the more relevant cases. Therefore, we assume that for \hat{x} , the second-order condition is satisfied, and thus, \hat{x} is unique.

[3] For further information concerning the projects, see the appendix.

III.5 Anhang

Anhang - Beitrag 3:

1. Derivation of the expected increases in cash inflows of making the inferior process more flexible $E_1[p(f_{\text{inf}})]$:

$$\begin{aligned}
 E_1[p(f_{\text{inf}})] &= \int_0^F C_{\text{inf}} T M_{\text{sup}} \cdot f_{\text{inf}} \cdot u(f_{\text{inf}}) df_{\text{inf}} + \left(1 - \frac{C_{\text{inf}} T}{D_{\text{sup}}^+} F_{\text{inf}}\right) \cdot C_{\text{inf}} T M_{\text{sup}} F_{\text{inf}} \\
 &= \int_0^F C_{\text{inf}} T M_{\text{sup}} \cdot \frac{C_{\text{inf}} T}{D_{\text{sup}}^+} f_{\text{inf}} df_{\text{inf}} + \left(1 - \frac{C_{\text{inf}} T}{D_{\text{sup}}^+} F_{\text{inf}}\right) \cdot C_{\text{inf}} T M_{\text{sup}} F_{\text{inf}} = \\
 &= \frac{M_{\text{sup}} C_{\text{inf}}^2 T^2}{D_{\text{sup}}^+} \int_0^F f_{\text{inf}} df_{\text{inf}} + \left(1 - \frac{C_{\text{inf}} T}{D_{\text{sup}}^+} F_{\text{inf}}\right) \cdot C_{\text{inf}} T M_{\text{sup}} F_{\text{inf}} \\
 &= \frac{M_{\text{sup}} C_{\text{inf}}^2 T^2}{D_{\text{sup}}^+} \left[\frac{f_{\text{inf}}^2}{2}\right]_0^F + \left(1 - \frac{C_{\text{inf}} T}{D_{\text{sup}}^+} F_{\text{inf}}\right) \cdot C_{\text{inf}} T M_{\text{sup}} F_{\text{inf}} \\
 &= \frac{M_{\text{sup}} C_{\text{inf}}^2 T^2}{2D_{\text{sup}}^+} \cdot F_{\text{inf}}^2 + M_{\text{sup}} C_{\text{inf}} T F_{\text{inf}} - \frac{M_{\text{sup}} C_{\text{inf}}^2 T^2}{D_{\text{sup}}^+} \cdot F_{\text{inf}}^2 \\
 &= M_{\text{sup}} C_{\text{inf}} T F_{\text{inf}} - \frac{M_{\text{sup}} C_{\text{inf}}^2 T^2}{2D_{\text{sup}}^+} \cdot F_{\text{inf}}^2
 \end{aligned} \tag{1}$$

2. Derivation of the expected decreases in cash inflows of making the inferior process more flexible in case of excess demand for the inferior process $E_{2.1}[o(f_{\text{inf}})]$:

$$\begin{aligned}
 E_{2.1}[o(f_{\text{inf}})] &= \int_0^F C_{\text{inf}} M_{\text{inf}} \cdot f_{\text{inf}} \cdot u(f_{\text{inf}}) df_{\text{inf}} + \left(1 - \frac{C_{\text{inf}} T}{D_{\text{sup}}^+} F_{\text{inf}}\right) \cdot C_{\text{inf}} M_{\text{inf}} F_{\text{inf}} \\
 &= \int_0^F C_{\text{inf}} M_{\text{inf}} \cdot \frac{C_{\text{inf}} T}{D_{\text{sup}}^+} f_{\text{inf}} df_{\text{inf}} + \left(1 - \frac{C_{\text{inf}} T}{D_{\text{sup}}^+} F_{\text{inf}}\right) \cdot C_{\text{inf}} M_{\text{inf}} F_{\text{inf}} = \\
 &= \frac{M_{\text{inf}} C_{\text{inf}}^2 T}{D_{\text{sup}}^+} \int_0^F f_{\text{inf}} df_{\text{inf}} + \left(1 - \frac{C_{\text{inf}} T}{D_{\text{sup}}^+} F_{\text{inf}}\right) \cdot C_{\text{inf}} M_{\text{inf}} F_{\text{inf}} \\
 &= \frac{M_{\text{inf}} C_{\text{inf}}^2 T}{D_{\text{sup}}^+} \left[\frac{f_{\text{inf}}^2}{2}\right]_0^F + \left(1 - \frac{C_{\text{inf}} T}{D_{\text{sup}}^+} F_{\text{inf}}\right) \cdot C_{\text{inf}} M_{\text{inf}} F_{\text{inf}} \\
 &= \frac{M_{\text{inf}} C_{\text{inf}}^2 T}{2D_{\text{sup}}^+} \cdot F_{\text{inf}}^2 + M_{\text{inf}} C_{\text{inf}} T F_{\text{inf}} - \frac{M_{\text{inf}} C_{\text{inf}}^2 T}{D_{\text{sup}}^+} \cdot F_{\text{inf}}^2 \\
 &= M_{\text{inf}} C_{\text{inf}} T F_{\text{inf}} - \frac{M_{\text{inf}} C_{\text{inf}}^2 T}{2D_{\text{sup}}^+} \cdot F_{\text{inf}}^2
 \end{aligned} \tag{2}$$

3. Derivation of the expected decreases in cash inflows of making the inferior process more flexible in case of a demand shortage for the inferior process given a level of realized flexibility $E_{1.2}[o(f_{\text{inf}})]$:

$$\begin{aligned}
 E_{1.2}[o(f_{\text{inf}})] &= \int_0^{C_{\text{inf}}f_{\text{inf}}} (C_{\text{inf}}f_{\text{inf}} - k_{\text{inf}}) \cdot M_{\text{inf}} \cdot u(k_{\text{inf}}) dk_{\text{inf}} = \int_0^{C_{\text{inf}}f_{\text{inf}}} (C_{\text{inf}}f_{\text{inf}} - k_{\text{inf}}) \cdot M_{\text{inf}} \cdot \frac{1}{D_{\text{inf}}^-} dk_{\text{inf}} \\
 &= \frac{M_{\text{inf}}}{D_{\text{inf}}^-} \int_0^{C_{\text{inf}}f_{\text{inf}}} (C_{\text{inf}}f_{\text{inf}} - k_{\text{inf}}) \cdot dk_{\text{inf}} = \frac{M_{\text{inf}}}{D_{\text{inf}}^-} \left[C_{\text{inf}}f_{\text{inf}}k_{\text{inf}} - \frac{k_{\text{inf}}^2}{2} \right]_0^{C_{\text{inf}}f_{\text{inf}}} = \frac{C_{\text{inf}}^2 M_{\text{inf}}}{2 D_{\text{inf}}^-} f_{\text{inf}}^2
 \end{aligned} \tag{3}$$

As already explained, an additional case analysis is necessary to fully specify the cash inflow decreases. If the flexibility potential for the inferior process exceeds $\frac{D_{\text{inf}}^-}{C_{\text{inf}}}$ (Case 1.2.2), the realized process flexibility of the inferior process f_{inf} can obviously also exceed this threshold. Consequently, the reallocated capacity $f_{\text{inf}} \cdot C_{\text{inf}}$ would then be larger than the maximal free capacity D_{inf}^- of the inferior process. In other words, the capacity of the inferior process would be reduced below the minimum demand. Clearly, the capacity reduction beyond the minimum demand lead to certain cash inflow reductions and have to be treated differently from capacity reductions up to the minimum demand which leads to uncertain cash inflow reductions. If the flexibility potential is smaller than $\frac{D_{\text{inf}}^-}{C_{\text{inf}}}$ (Case 1.2.1), the capacity of the inferior process is definitely not reduced below the minimum demand. As a consequence, the cash inflow reductions are always uncertain. A different treatment for realized process flexibilities is not mandatory.

First, we analyze those levels of the realized flexibility that are smaller than the threshold (Case 1.2.2). To obtain the expected cash inflow decreases, the function $E_{1.2}[o(f_{\text{inf}})]$ (the expected decreases in cash inflows given a realized level of flexibility of the inferior process f_{inf}) is integrated over the density function of the flexibility of the inferior process. This covers all excess demand realizations that can be covered by the chosen level of flexibility. Again, larger realizations are considered as well.

$$\begin{aligned}
E_{1.2.1}[o(f_{\text{inf}})] &= \int_0^{F_{\text{inf}}} E_{1.2}[o(f_{\text{inf}})] \cdot u(f_{\text{inf}}) df_{\text{inf}} + \left(1 - \frac{C_{\text{inf}} T}{D_{\text{sup}}^+} F_{\text{inf}}\right) \cdot E_{1.2}[o(f_{\text{inf}} = F_{\text{inf}})] \\
&= \int_0^{F_{\text{inf}}} \frac{C_{\text{inf}}^2 M_{\text{inf}}}{2 D_{\text{inf}}^-} \cdot \frac{C_{\text{inf}} \cdot T}{D_{\text{sup}}^+} f_{\text{inf}}^2 df_{\text{inf}} + \left(1 - \frac{C_{\text{inf}} T}{D_{\text{sup}}^+} F_{\text{inf}}\right) \cdot \frac{C_{\text{inf}}^2 M_{\text{inf}}}{2 D_{\text{inf}}^-} F_{\text{inf}}^2 \\
&= \frac{C_{\text{inf}}^3 T M_{\text{inf}}}{2 D_{\text{inf}}^- D_{\text{sup}}^+} \int_0^{F_{\text{inf}}} f_{\text{inf}}^2 df_{\text{inf}} + \left(1 - \frac{C_{\text{inf}} T}{D_{\text{sup}}^+} F_{\text{inf}}\right) \cdot \frac{C_{\text{inf}}^2 M_{\text{inf}}}{2 D_{\text{inf}}^-} F_{\text{inf}}^2 \\
&= \frac{C_{\text{inf}}^3 T M_{\text{inf}}}{2 D_{\text{inf}}^- D_{\text{sup}}^+} \left[\frac{f_{\text{inf}}^3}{3} \right]_0^{F_{\text{inf}}} + \left(1 - \frac{C_{\text{inf}} T}{D_{\text{sup}}^+} F_{\text{inf}}\right) \cdot \frac{C_{\text{inf}}^2 M_{\text{inf}}}{2 D_{\text{inf}}^-} F_{\text{inf}}^2 \\
&= \frac{C_{\text{inf}}^3 T M_{\text{inf}}}{6 D_{\text{inf}}^- D_{\text{sup}}^+} F_{\text{inf}}^3 + \frac{C_{\text{inf}}^2 M_{\text{inf}}}{2 D_{\text{inf}}^-} F_{\text{inf}}^2 - \frac{C_{\text{inf}}^3 T M_{\text{inf}}}{2 D_{\text{inf}}^- D_{\text{sup}}^+} F_{\text{inf}}^3 = \frac{C_{\text{inf}}^2 M_{\text{inf}}}{2 D_{\text{inf}}^-} F_{\text{inf}}^2 - \frac{C_{\text{inf}}^3 T M_{\text{inf}}}{3 D_{\text{inf}}^- D_{\text{sup}}^+} F_{\text{inf}}^3
\end{aligned} \tag{4}$$

Second, we analyze those levels of flexibility potentials of the inferior process that exceed the threshold (Case 1.2.2). As already stated, levels of realized flexibility of the inferior process below and above the separating threshold have to be treated differently. The expected cash inflow decreases are a combination of the formulas derived so far. For levels of realized flexibility of the inferior process smaller than the threshold, the decreases of the cash inflows are uncertain and function (4) can be applied. For flexibility realizations larger than the threshold, the additional capacity reductions beyond the minimum demand lead to certain decreases of the cash inflows from the sales of the inferior output. Therefore, formula (2) can be used because this equation considers certain reductions of cash inflows as well. The only difference is that formula (2) does not consider free capacity because it just does not occur in cases of excess demand for the superior process. As the free capacity does not decrease the cash inflows, we have to adjust formula (2) to fit it to the case of shortage demand. The expected free capacity for levels of realized flexibility of the inferior process exceeding the threshold is given by the uniform distribution of the free capacity and equals $\frac{1}{2u(k_{\text{inf}})} = \frac{D_{\text{inf}}^-}{2}$. In terms of expected values, the reductions of the cash inflows are certain after an adjustment of $\frac{D_{\text{inf}}^-}{2} \cdot M_{\text{inf}}$. Therefore, the expected reduction of the cash inflows for levels of flexibility of the inferior process exceeding $\frac{D_{\text{inf}}^-}{C_{\text{inf}}}$ equal:

$$\begin{aligned}
E_{1.2.2}[o(f_{\text{inf}})] &= \int_0^{\frac{D_{\text{inf}}^-}{C_{\text{inf}}}} E_{1.2}[o(f_{\text{inf}})] \cdot u(f_{\text{inf}}) df_{\text{inf}} + \int_{\frac{D_{\text{inf}}^-}{C_{\text{inf}}}}^{F_{\text{inf}}} \left(C_{\text{inf}} M_{\text{inf}} f_{\text{inf}} - \frac{D_{\text{inf}}^-}{2} \cdot M_{\text{inf}} \right) \cdot u(f_{\text{inf}}) df_{\text{inf}} \\
&+ \left(1 - \frac{C_{\text{inf}} T}{D_{\text{sup}}^+} F_{\text{inf}} \right) \cdot \left(C_{\text{inf}} M_{\text{inf}} F_{\text{inf}} - \frac{D_{\text{inf}}^-}{2} \cdot M_{\text{inf}} \right) \\
&= \int_0^{\frac{D_{\text{inf}}^-}{C_{\text{inf}}}} \frac{C_{\text{inf}}^2 M_{\text{inf}}}{2 D_{\text{inf}}^-} \cdot \frac{C_{\text{inf}} T}{D_{\text{sup}}^+} f_{\text{inf}}^2 df_{\text{inf}} + \int_{\frac{D_{\text{inf}}^-}{C_{\text{inf}}}}^{F_{\text{inf}}} \left(C_{\text{inf}} M_{\text{inf}} f_{\text{inf}} - \frac{D_{\text{inf}}^-}{2} \cdot M_{\text{inf}} \right) \cdot \frac{C_{\text{inf}} T}{D_{\text{sup}}^+} df_{\text{inf}} \\
&+ \left(1 - \frac{C_{\text{inf}} T}{D_{\text{sup}}^+} F_{\text{inf}} \right) \cdot \left(C_{\text{inf}} M_{\text{inf}} F_{\text{inf}} - \frac{D_{\text{inf}}^-}{2} \cdot M_{\text{inf}} \right) \\
&= \frac{C_{\text{inf}}^3 T M_{\text{inf}}}{2 D_{\text{inf}}^- D_{\text{sup}}^+} \int_0^{\frac{D_{\text{inf}}^-}{C_{\text{inf}}}} f_{\text{inf}}^2 \cdot df_{\text{inf}} + \frac{M_{\text{inf}} C_{\text{inf}}^2 T}{D_{\text{sup}}^+} \int_{\frac{D_{\text{inf}}^-}{C_{\text{inf}}}}^{F_{\text{inf}}} f_{\text{inf}} df_{\text{inf}} - \frac{D_{\text{inf}}^- C_{\text{inf}} T \cdot M_{\text{inf}}}{2 D_{\text{sup}}^+} \int_{\frac{D_{\text{inf}}^-}{C_{\text{inf}}}}^{F_{\text{inf}}} df_{\text{inf}} \\
&+ \left(1 - \frac{C_{\text{inf}} T}{D_{\text{sup}}^+} F_{\text{inf}} \right) \cdot \left(C_{\text{inf}} M_{\text{inf}} F_{\text{inf}} - \frac{D_{\text{inf}}^-}{2} \cdot M_{\text{inf}} \right) = \frac{C_{\text{inf}}^3 T M_{\text{inf}}}{2 D_{\text{inf}}^- D_{\text{sup}}^+} \left[\frac{f_{\text{inf}}^3}{3} \right]_{\frac{D_{\text{inf}}^-}{C_{\text{inf}}}}^0 \\
&+ \frac{C_{\text{inf}}^2 T M_{\text{inf}}}{D_{\text{sup}}^+} \left[\frac{f_{\text{inf}}^2}{2} \right]_{\frac{D_{\text{inf}}^-}{C_{\text{inf}}}}^{F_{\text{inf}}} - \frac{D_{\text{inf}}^- C_{\text{inf}} T \cdot M_{\text{inf}}}{2 D_{\text{sup}}^+} [f_{\text{inf}}]_{\frac{D_{\text{inf}}^-}{C_{\text{inf}}}}^{F_{\text{inf}}} + \left(1 - \frac{C_{\text{inf}} T}{D_{\text{sup}}^+} F_{\text{inf}} \right) \\
&\cdot \left(C_{\text{inf}} M_{\text{inf}} F_{\text{inf}} - \frac{D_{\text{inf}}^-}{2} \cdot M_{\text{inf}} \right) \\
&= \frac{(D_{\text{inf}}^-)^2 T}{6 D_{\text{sup}}^+} \cdot M_{\text{inf}} + \frac{M_{\text{inf}} C_{\text{inf}}^2 T}{2 D_{\text{sup}}^+} \cdot F_{\text{inf}}^2 - \frac{(D_{\text{inf}}^-)^2 T}{2 D_{\text{sup}}^+} \cdot M_{\text{inf}} - \frac{D_{\text{inf}}^- C_{\text{inf}} T \cdot M_{\text{inf}}}{2 D_{\text{sup}}^+} F_{\text{inf}} \\
&+ \frac{(D_{\text{inf}}^-)^2 T}{2 D_{\text{sup}}^+} \cdot M_{\text{inf}} + C_{\text{inf}} M_{\text{inf}} F_{\text{inf}} - \frac{M_{\text{inf}} C_{\text{inf}}^2 T}{D_{\text{sup}}^+} \cdot F_{\text{inf}}^2 + \frac{D_{\text{inf}}^- C_{\text{inf}} T \cdot M_{\text{inf}}}{2 D_{\text{sup}}^+} F_{\text{inf}} - \frac{D_{\text{inf}}^-}{2} \cdot M_{\text{inf}} \\
&= -\frac{D_{\text{inf}}^-}{2} \cdot M_{\text{inf}} + \frac{(D_{\text{inf}}^-)^2 T}{6 D_{\text{sup}}^+} \cdot M_{\text{inf}} + C_{\text{inf}} M_{\text{inf}} F_{\text{inf}} - \frac{M_{\text{inf}} C_{\text{inf}}^2 T}{2 D_{\text{sup}}^+} \cdot F_{\text{inf}}^2
\end{aligned} \tag{5}$$

4. Derivation of the expected increases of the cash inflows of the inferior process by making the superior process more flexible given a level of realizable flexibilization

$$E_{2.1}(p(f_{\text{sup}})):$$

$$\begin{aligned}
E_{2.1}(p(f_{\text{sup}})) &= \int_0^{\frac{C_{\text{sup}}}{T} f_{\text{sup}}} l_{\text{inf}} \cdot M_{\text{inf}} u(l_{\text{inf}}) dl_{\text{inf}} + \left(1 - \frac{C_{\text{sup}}}{T D_{\text{inf}}^+} f_{\text{sup}} \right) p(f_{\text{sup}}) \\
&= \frac{M_{\text{inf}}}{D_{\text{inf}}^+} \int_0^{\frac{C_{\text{sup}}}{T} f_{\text{sup}}} l_{\text{inf}} dl_{\text{inf}} + \left(1 - \frac{C_{\text{sup}}}{T D_{\text{inf}}^+} f_{\text{sup}} \right) \frac{C_{\text{sup}} M_{\text{inf}}}{T} f_{\text{sup}} \\
&= \frac{M_{\text{inf}}}{D_{\text{inf}}^+} \left[\frac{l_{\text{inf}}^2}{2} \right]_0^{\frac{C_{\text{sup}}}{T} f_{\text{sup}}} + \left(1 - \frac{C_{\text{sup}}}{T D_{\text{inf}}^+} f_{\text{sup}} \right) \frac{C_{\text{sup}} M_{\text{inf}}}{T} f_{\text{sup}} \\
&= \frac{C_{\text{sup}}^2 M_{\text{inf}}}{2 T^2 D_{\text{inf}}^+} f_{\text{sup}}^2 + \frac{C_{\text{sup}} M_{\text{inf}}}{T} f_{\text{sup}} - \frac{C_{\text{sup}}^2 M_{\text{inf}}}{T^2 D_{\text{inf}}^+} f_{\text{sup}}^2 = \frac{C_{\text{sup}} M_{\text{inf}}}{T} f_{\text{sup}} - \frac{C_{\text{sup}}^2 M_{\text{inf}}}{2 T^2 D_{\text{inf}}^+} f_{\text{sup}}^2
\end{aligned} \tag{6}$$

5. Derivation of the periodic increases of cash inflows of the inferior process by making the superior process more flexible given a level flexibility potential $I_{\text{sup}}^{\text{periodic}}(F_{\text{sup}})$:

$$\begin{aligned}
I_{\text{sup}}^{\text{periodic}}(F_{\text{sup}}) &= \text{Prob}_{2.1} \left[\int_0^{F_{\text{sup}}} \left(\frac{C_{\text{sup}} M_{\text{inf}}}{T} f_{\text{sup}} - \frac{C_{\text{sup}}^2 M_{\text{inf}}}{2T^2 D_{\text{inf}}^+} f_{\text{sup}}^2 \right) u(f_{\text{sup}}) df_{\text{sup}} \right. \\
&\quad \left. + \left(1 - \frac{C_{\text{sup}}}{D_{\text{sup}}^-} F_{\text{sup}} \right) \left(\frac{C_{\text{sup}} M_{\text{inf}}}{T} F_{\text{sup}} - \frac{C_{\text{sup}}^2 M_{\text{inf}}}{2T^2 D_{\text{inf}}^+} F_{\text{sup}}^2 \right) \right] \\
&= \text{Prob}_{2.1} \left[\frac{C_{\text{sup}}^2 M_{\text{inf}}}{D_{\text{sup}}^- T} \int_0^{F_{\text{sup}}} f_{\text{sup}} df_{\text{sup}} - \frac{C_{\text{sup}}^3 M_{\text{inf}}}{2T^2 D_{\text{sup}}^- D_{\text{inf}}^+} \int_0^{F_{\text{sup}}} f_{\text{sup}}^2 df_{\text{sup}} \right. \\
&\quad \left. + \left(1 - \frac{C_{\text{sup}}}{D_{\text{sup}}^-} F_{\text{sup}} \right) \left(\frac{C_{\text{sup}} M_{\text{inf}}}{T} F_{\text{sup}} - \frac{C_{\text{sup}}^2 M_{\text{inf}}}{2T^2 D_{\text{inf}}^+} F_{\text{sup}}^2 \right) \right] \\
&= \text{Prob}_{2.1} \left[\frac{C_{\text{sup}}^2 M_{\text{inf}}}{D_{\text{sup}}^- T} \left[\frac{f_{\text{sup}}^2}{2} \right]_0^{F_{\text{sup}}} F_{\text{sup}} - \frac{C_{\text{sup}}^3 M_{\text{inf}}}{2T^2 D_{\text{sup}}^- D_{\text{inf}}^+} \left[\frac{f_{\text{sup}}^3}{3} \right]_0^{F_{\text{sup}}} F_{\text{sup}} \right. \\
&\quad \left. + \left(1 - \frac{C_{\text{sup}}}{D_{\text{sup}}^-} F_{\text{sup}} \right) \left(\frac{C_{\text{sup}} M_{\text{inf}}}{T} F_{\text{sup}} - \frac{C_{\text{sup}}^2 M_{\text{inf}}}{2T^2 D_{\text{inf}}^+} F_{\text{sup}}^2 \right) \right] \tag{7} \\
&= \text{Prob}_{2.1} \left[\frac{C_{\text{sup}}^2 M_{\text{inf}}}{2TD_{\text{sup}}^-} F_{\text{sup}}^2 - \frac{C_{\text{sup}}^3 M_{\text{inf}}}{6T^2 D_{\text{sup}}^- D_{\text{inf}}^+} F_{\text{sup}}^3 + \frac{C_{\text{sup}} M_{\text{inf}}}{T} F_{\text{sup}} - \frac{C_{\text{sup}}^2 M_{\text{inf}}}{2T^2 D_{\text{inf}}^+} F_{\text{sup}}^2 \right. \\
&\quad \left. - \frac{C_{\text{sup}}^2 M_{\text{inf}}}{D_{\text{sup}}^- T} F_{\text{sup}}^2 + \frac{C_{\text{sup}}^3 M_{\text{inf}}}{2T^2 D_{\text{sup}}^- D_{\text{inf}}^+} F_{\text{sup}}^3 \right] \\
&= \text{Prob}_{2.1} \left[\frac{C_{\text{sup}} M_{\text{inf}}}{T} F_{\text{sup}} - \frac{C_{\text{sup}}^2 M_{\text{inf}}}{2T^2 D_{\text{inf}}^+} F_{\text{sup}}^2 - \frac{C_{\text{sup}}^2 M_{\text{inf}}}{2TD_{\text{sup}}^-} F_{\text{sup}}^2 + \frac{C_{\text{sup}}^3 M_{\text{inf}}}{3T^2 D_{\text{sup}}^- D_{\text{inf}}^+} F_{\text{sup}}^3 \right]
\end{aligned}$$

6. Derivations of the optimal levels of flexibility potentials

6.1 Optimal flexibility potential of the inferior process

For the derivation of the optimal level of flexibility potential of the inferior process, the objective function of the investment has to be determined first. Therefore, the corresponding periodic cash inflows have to be multiplied with the discount factor to obtain the risk adjusted present value from the cash inflows $I_{\text{inf}}(F_{\text{inf}})$. From the intermediate result, the cash outflows are subtracted to determine the risk adjusted net present value of a flexibility potential. The objective function can then be derived with respect to the flexibility potential. By setting the first derivative equal to zero and resolving the equation with respect to the flexibility potential of the inferior process. Because of the case distinction, this procedure has to be executed twice.

$$\begin{aligned}
\text{For } F_{\text{inf}} \leq \frac{D_{\text{inf}}^-}{C_{\text{inf}}}: \quad & \frac{\partial \delta I_{\text{inf}}^{\text{periodic}}(F_{\text{inf}}) - C(F_{\text{inf}})}{\partial F_{\text{inf}}} \\
& = \left(\frac{C_{\text{inf}}^2 T M_{\text{inf}}}{D_{\text{inf}}^- D_{\text{sup}}^+} \text{Prob}_{1.2} \right) \cdot F_{\text{inf}}^*{}^2 \\
& + \left(- \frac{M_{\text{sup}} C_{\text{inf}} T^2}{D_{\text{sup}}^+} \text{Prob}_1 - \frac{2G_{\text{inf}} r_{\text{inf}}}{\delta} - \frac{C_{\text{inf}} M_{\text{inf}}}{D_{\text{inf}}^-} \text{Prob}_{1.2} + \frac{M_{\text{inf}} C_{\text{inf}} T}{D_{\text{sup}}^+} \text{Prob}_{1.1} \right) F_{\text{inf}}^* \\
& + (\text{Prob}_1 M_{\text{sup}} T - \text{Prob}_{1.1} M_{\text{inf}}) = 0
\end{aligned} \tag{8}$$

Equation (8) can be resolved with respect to the flexibility potential of the inferior process by applying the solution formula for quadratic equations:

$$\begin{aligned}
\text{For } F_{\text{inf}} \leq \frac{D_{\text{inf}}^-}{C_{\text{inf}}}: \quad & F_{\text{inf}}^* = \\
& = \frac{\frac{M_{\text{sup}} C_{\text{inf}} T^2}{D_{\text{sup}}^+} \text{Prob}_1 + \frac{2Gr}{\delta} + \frac{C_{\text{inf}} M_{\text{inf}}}{D_{\text{inf}}^-} \text{Prob}_{1.2} - \frac{M_{\text{inf}} C_{\text{inf}} T}{D_{\text{sup}}^+} \text{Prob}_{1.1}}{\frac{2C_{\text{inf}}^2 T M_{\text{inf}}}{D_{\text{inf}}^- D_{\text{sup}}^+} \text{Prob}_{1.2}} \\
& - \sqrt{\frac{\left(- \frac{2M_{\text{sup}} C_{\text{inf}} T^2}{D_{\text{sup}}^+} \text{Prob}_1 - \frac{2G_{\text{inf}} r_{\text{inf}}}{\delta} - \frac{C_{\text{inf}} M_{\text{inf}}}{D_{\text{inf}}^-} \text{Prob}_{1.2} + \frac{M_{\text{inf}} C_{\text{inf}} T}{D_{\text{sup}}^+} \text{Prob}_{1.1} \right)^2 - \text{Prob}_{1.2} \frac{4C_{\text{inf}}^2 T M_{\text{inf}}}{D_{\text{inf}}^- D_{\text{sup}}^+} \cdot (\text{Prob}_1 M_{\text{sup}} T - \text{Prob}_{1.1} M_{\text{inf}})}{\frac{2C_{\text{inf}}^2 T M_{\text{inf}}}{D_{\text{inf}}^- D_{\text{sup}}^+} \text{Prob}_{1.2}}}
\end{aligned} \tag{9}$$

Now the same approach is used for values of the flexibility potential exceeding the case distinction threshold:

$$\begin{aligned}
\text{For } F_{\text{inf}} > \frac{D_{\text{inf}}^-}{C_{\text{inf}}}: \quad & \frac{\partial \delta I_{\text{inf}}^{\text{periodic}}(F_{\text{inf}}) - C(F_{\text{inf}})}{\partial F_{\text{inf}}} \\
& = - \left(\frac{C_{\text{inf}} T}{D_{\text{sup}}^+} \cdot \text{Prob}_1 \cdot (M_{\text{sup}} T - M_{\text{inf}}) + \frac{2G_{\text{inf}} r_{\text{inf}}}{\delta} \right) F_{\text{inf}}^* + \text{Prob}_1 \cdot (M_{\text{sup}} T - M_{\text{inf}}) = 0
\end{aligned} \tag{10}$$

Again resolving equation (10) with respect to the optimal flexibility potential of the inferior process determines the optimum:

$$\text{For } F_{\text{inf}} > \frac{D_{\text{inf}}^-}{C_{\text{inf}}}: \quad F_{\text{inf}}^* = \frac{(\text{Prob}_1 M_{\text{sup}} T - M_{\text{inf}})}{\frac{C_{\text{inf}} T}{D_{\text{sup}}^+} \cdot (\text{Prob}_1 M_{\text{sup}} T - M_{\text{inf}}) + \frac{2G_{\text{inf}} r_{\text{inf}}}{\delta}} \tag{11}$$

6.2 Optimal flexibility potential of the superior process

For the derivation of the optimal level of flexibility potential of the superior process, the same approach is applied as for the optimal flexibility of the inferior process:

$$\frac{\partial \delta I_{\text{sup}}^{\text{periodic}}(F_{\text{sup}}) - C(F_{\text{sup}})}{\partial F_{\text{sup}}} = \left(\frac{C_{\text{sup}}^2}{TD_{\text{sup}}^- D_{\text{inf}}^+} \right) \cdot F_{\text{sup}}^*{}^2 - \left(\frac{C_{\text{sup}}}{TD_{\text{inf}}^+} + \frac{C_{\text{sup}}}{D_{\text{sup}}^-} + \frac{2TG_{\text{sup}}r_{\text{sup}}}{Prob_{2.1}\delta M_{\text{inf}}} \right) F_{\text{sup}}^* + 1 = 0 \quad (12)$$

Using again the solution formula for quadratic equations the optimal flexibility of the superior process can be determined:

$$F_{\text{sup}}^* = \frac{\frac{C_{\text{sup}}}{TD_{\text{inf}}^+} + \frac{C_{\text{sup}}}{D_{\text{sup}}^-} + \frac{2TG_{\text{sup}}r_{\text{sup}}}{Prob_{2.1}\delta M_{\text{inf}}} - \sqrt{\left(\frac{C_{\text{sup}}}{TD_{\text{inf}}^+} + \frac{C_{\text{sup}}}{D_{\text{sup}}^-} + \frac{2TG_{\text{sup}}r_{\text{sup}}}{Prob_{2.1}\delta M_{\text{inf}}} \right)^2 - 4 \frac{C_{\text{sup}}^2}{TD_{\text{sup}}^- D_{\text{inf}}^+}}}{2 \frac{C_{\text{sup}}^2}{TD_{\text{sup}}^- D_{\text{inf}}^+}} \quad (13)$$

Anhang A2 – Beitrag 5:

No.	Project name	Return*	Cost*	Project Size* (Person days)
1	Order Post Processing	961,349 €	68,250 €	60
2	Obligatory Corporate Action	98,439 €	36,400 €	24
3	Maturity Capacity to Contract	31,316 €	9,100 €	8
4	Automatic Branching of	69,738 €	22,750 €	20
5	Deposit Pricing during the Year	465,954 €	182,000 €	160
6	Quotas	216,956 €	182,000 €	160
7	Book-Entry Transfers—Advisor	23,522 €	36,400 €	32
8	Manual Order Cancellation	234,949 €	558,285 €	480
9	Book-Entry Transfers—Advisor	12,194 €	417,690 €	360
10	Discounts	460 €	68,250 €	60
11	Order Cancellation Finishing	-	13,650 €	12
12	Provisioning	-	31,850 €	28
13	Account Closing	-	45,500 €	40
14	Security Transaction on Savings	-	22,750 €	20
15	Order Entry for Annual	-	191,100 €	168
16	Sales Communications	-	13,650 €	12
17	Order Collections from Asset	-	93,730 €	64
18	Rights Issues Repository	-	13,650 €	12

* for phases Analysis and Modeling; cost values and project sizes for manual process redesign

III.6 Literatur

- Adenso-Diaz, B., Gonzáles-Torre, P., and Garcia, V. 2002. „A Capacity Management Model in Service Industries,” in *International Journal of Service Industry Management* (13:3), pp. 286-302.
- Afflerbach, P., Kastner, G., Krause, F., and Röglinger, R. 2013. „An Optimization Model for Valuating Process Flexibility,” in *Proceedings of the 34th International Conference on Information Systems*, Milan
- Agostini, A., and De Michelis, G. 2000. „A Light Workflow Management System Using Simple Process Models,” in *Computer Supported Cooperative Work* (9:3-4), pp. 335-363.
- Ahmad, H., Francis, A., and Zairi, M. 2007. „Business Process Reengineering: Critical Success Factors in Higher Education,” in *Business Process Management Journal* (13:3), pp. 451-469.
- Aksin, O. Z., de Véricourt, F., and Karaesmen, F. 2008. „Call Center Outsourcing Contract Analysis and Choice,” in *Management Science* (54:2), pp. 354-368.
- Alter, S. 2010. „Viewing Systems as Services: A Fresh Approach in the IS Field,” in *Communications of the AIS*, (26:11), pp. 195-224.
- Alter, S. 2013. „Work System Theory: Overview of Core Concepts, Extensions, and Challenges for the Future,” in *Journal of the Association for Information Systems* (14:2), pp. 72-121.
- Amram, M., and Kulatilaka, N. 1998. *Real Options: Managing Strategic Investment in an Uncertain World*, Cambridge, USA, Harvard Business School Press.
- Anupindi, R., Chopra, S., Deshmukh, S.D., Van Mieghem, J.A., and Zemel, E. 2012. *Managing Business Process Flows: Principles of Operations Management*, New York, USA, Prentice Hall.
- Arrott, M., Demchak, B., Ermagan, V., Farcas, C., Farcas, E., Kruger I. H., and Menarini, M. 2007. „Rich Services: The Integration Piece of the SOA Puzzle,” in *Proceedings of the 5th IEEE International Conference on Web Services*, July 2007, Utah, USA, pp. 176-183.

-
- Arrow, K. 1962. „Economic Welfare and the Allocation of Resources for Invention,” in *The Rate and Direction of Inventive Activity: Economic and Social Factors*, Princeton, USA, NBER, pp. 609-626.
- Becker, A., Buxmann, P. and Widjaja, T. 2011. „Value Potential and Challenges of Service-Oriented Architectures,” in *Business & Information Systems Engineering*, (3:4), pp.199-210.
- Becker, J., Kahn D. 2003. „The Process in Focus,” in *Process Management. A Guide for the Design of Business Processes*, Berlin, Germany, Springer, pp. 1-12
- Beimborn, D., Joachim N., and Weitzel, T. 2008. „Drivers and Inhibitors of SOA Business Value - Conceptualizing a Research Model,” in *Proceedings of the 14th Americas Conference on Information Systems*, August 2008, Toronto, Canada.
- Benaroch, M., Qizhi, D., and Kauffman, R. J. 2010. „Should We Go Our Own Way? Backsourcing Flexibility in IT Services Contracts,” in *Journal of Management Information Systems*, (26:4), 317-358.
- Bengtsson, J. 2001. „Manufacturing Flexibility and Real Options: a Review,” in *International Journal of Production Economics*, (74:1), pp. 213-224.
- Berger, J. O. 2010. *Statistical Decision Theory and Bayesian Analysis*, New York, USA, Springer.
- Betz, S., Klink S., Koschmider A., and Oberweis A. 2006. „Automatic user support for business process modeling,” in *Proceedings of the 3rd European Semantic Web Conference*, June 2006, Budva, Montenegro, pp. 1-12.
- Black, F. and Scholes, M. J. 1973. „The Pricing of Options and Corporate Liabilities,” in *Journal of Political Economy*, (81:3), pp. 637-654.
- Boehm, B.W. 1981. *Software engineering economics*, New Jersey, USA, Prentice Hall PTR.
- Bolsinger, M., Bewernik M., and Buhl H.U. 2011. „Value-Based Process Improvement,” in *Proceedings of the 19th European Conference on Information Systems*, June 2011, Helsinki, Finland.
- Bordoloi, S. K., Cooper, W. W., and Matsuo, H. 1999. „Flexibility, Adaptability, and Efficiency in Manufacturing Systems,” in *Production and Operations Management* (8:2), pp. 133-150.

-
- Braunwarth, K. and Ullrich, C. 2010. „Valuating Business Process Flexibility Achieved through an Alternative Execution Path,” in *Proceedings of the 18th European Conference on Information Systems*, June 2010, Pretoria, South Africa.
- Braunwarth, K. S., Kaiser, M., and Müller, A.-L. 2010. „Economic Evaluation and Optimization of the Degree of Automation in Insurance Processes,” in *Business and Information Systems Engineering* (2:1), pp. 29-39.
- Brockmans, S., Ehrig M., Koschmider A., Oberweis A. and Studer R. 2006. „Semantic Alignment of Business Processes” in *Proceedings of the 8th International Conference on Enterprise Information Systems*, May 2006, Paphos, Cyprus, pp. 191-196.
- Buhl, H. U.; Dorsch, C. and Henneberger, M. 2011. „Multiple-Sourcing-Strategien bei Finanzdienstleistern – Eine Analyse zum Einfluss der Integrationskosten am Beispiel der Wertpapierabwicklung,” in *Die Unternehmung* (64:4), pp. 334-351.
- Buhl, H.U., Röglinger M., Stöckl S., Braunwarth K. 2011. „Value Orientation in Process Management - Research Gap and Contribution to Economically Well-Founded Decisions in Process Management,” in *Business and Information Systems Engineering* (3:3), pp. 163-172.
- Cappelli, P., Neumark, D. 2004. “External Churning and Internal Flexibility: Evidence on the Functional Flexibility and Core-Periphery Hypotheses,” in *Industrial Relations: A Journal of Economy and Society* (43:1), pp. 148-182.
- Chanopas, A., Krairit, D., and Khang, D. 2006. „Managing Information Technology Infrastructure: A New Flexibility Framework,” in *Management Research News* (29:10), pp. 632-651.
- Cheng, T., Podolsky, S. 1996. *Just-in-Time Manufacturing: An introduction*, London, UK, Chapman & Hall.
- Chesbrough, H., and Spohrer, J. 2006. „A Research Manifesto for Services Science,” in *Communications of the Association for Computing Machinery* (49:7), pp. 35-40.
- Copeland, T. E., and Antikarov, V. 2003. *Real Options – A Practitioner's Guide*, New York, USA, Cengage Learning.
- Copeland, T. E., Koller, T., and Murrin, J. 1990. *Valuation: Measuring and Managing the Value of Companies*, New York, USA, Wiley.

-
- Cox, J. C. and Ross, S. A. 1975. „The Pricing of Options For jump Processes,” Rodney L. White Center, Working Paper no. 2-75, University of Pennsylvania, Philadelphia, USA.
- Cox, J. C. and Ross, S. A. 1976. „The Valuation of Options for Alternative Stochastic Processes,” in *Journal of Financial Economics*, (3:1), pp. 145-166.
- Curry, G., Feldmann, R. 2011. *Manufacturing Systems Modeling and Analysis*, Berlin, Heidelberg, Germany, Springer.
- De Toni, A., and Tonchia, S. 1998. „Manufacturing Flexibility: A Literature Review,” in *International Journal of Production Research* (36:6), pp. 1587-1617.
- Dumas, M., La Rosa, M., Mendling, J., Reijers, H. 2013. *Fundamentals of Business Process Management*, Heidelberg, Germany, Springer.
- Easton, F. F. 2011. “Cross-Training Performance in Flexible Labor Scheduling Environments,” in *IIE Transactions* (43:8), pp. 589-603.
- Eisenbarth, T., Lautenbacher F., Bauer B. 2011. „Adaptation of Process Models - a Semantic-Based Approach,” in *Journal of Research and Practice in Information Technology* (43:1), pp. 5-23.
- Fitzsimmons, J. A., and Fitzsimmons, M. J. 2011. *Service Management for Competitive Advantage*, New York, USA, McGraw-Hill.
- Fitzsimmons, J. A.; Fitzsimmons, M. J. 2010. *Service Management: Operations, Strategy, Information Technology*, New York, USA, McGraw-Hill.
- Fremantle, P., Weerawarana, S., and Khalaf, R. 2002. „Enterprise Services,” in *Communications of the ACM*, (45:10), pp. 77-82.
- Gans, N., Koole, G., and Mandelbaum, A. 2002. „Telephone Call Centers: Tutorial, Review, and Research Prospects,” in: *Manufacturing & Service Operations Management*, (5:2), pp. 79-141.
- Garnett, O., Mandelbaum, A., and Reiman, M. 2002. „Designing a Call Center with Impatient Customers,” in: *Manufacturing & Service Operations Management*, (9:1), pp. 33-50.
- Gartner (2010) „Leading in times of transition: the 2010 CIO agenda,”
http://drishtikone.com/files/2010CIOAgenda_ExecSummary.pdf, October 27, 2011.

-
- Gebauer, J. and Schober, F. 2006. „Information System Flexibility and the Cost Efficiency of Business Processes,” in *Journal of the Association for Information Systems* (7:3), p. 122-147.
- Gong, Y., and Janssen, M. 2010. „Measuring Process Flexibility and Agility,” in *Proceedings of the 4th International Conference on Theory and Practice of Electronic Governance*, October 2010, Beijing, China, pp. 173-182.
- Gosling, J., Purvis, L., and Naim, M. M. 2009. „Supply Chain Flexibility as a Determinant of Supplier Selection,” in *International Journal of Production Economics*, (128:1), pp.11-21.
- Gottschalk F., van der Aalst, W.P.M, Jansen-Vullers, M.H. 2007. „Configurable Process Models – A foundational Approach,” in *Reference Modeling*, Berlin, Germany, Springer, pp. 59-77.
- Goyal, M., and Netessine, S. 2011. „Volume Flexibility, Product Flexibility, or Both: The Role of Demand Correlation and Product Substitution,” in *Manufacturing and Service Operations Management* (13:2), pp. 180-193.
- Gross, D., Shortle, J., Thompson, J., and Harris, C. 2008. *Fundamentals of Queuing Theory*, Hoboken, USA, John Wiley & Sons Inc.
- Guilding, C., Drury, C., and Tayles, M. 2005. „An Empirical Investigation of the Importance of Cost-Plus Pricing,” in *Managerial Auditing Journal* (20:2), pp. 125-137.
- Gupta, Y. P. and Goyal, S. 1989. „Flexibility of Manufacturing Systems: Concepts and Measurement,” in *European Journal of Operational Research*, (43:2), pp. 119-135.
- Häckel, B., and Dorsch, C. 2012. „Integrating Business Partners on Demand: The Effect on Capacity Planning for Cost Driven Support Processes,” in *Proceedings of the 45th Hawaii International Conference on System Sciences*, January 2012, Maui, USA, pp.4796-4805.
- Häckel, B. and Dorsch, C. 2014. „Combining Models of Capacity Supply to Handle Volatile Demand: The Economic Impact of Surplus Capacity in Cloud Service Environments,” in *Decision Support Systems* (58:2), pp. 3-14.

-
- Hammer, M. 2010. „What is Business Process Management?,” in *Handbook on Business Process Management I: Introduction, Methods, and Information Systems*, Heidelberg, Germany, Springer, pp. 3-16.
- Hammer, M., and Champy J. 1995. *Reengineering the corporation*, London, UK, Nicholas Brealey Publishing Limited.
- Haniewicz, K., Kaczmarek M., Zyskowski D. (2008) „Semantic Web Services Applications – a Reality Check,” in *Business and Information Systems Engineering* (50:1), pp. 39-46.
- Harmon, P. 2010. *Business Process Change*, Burlington, USA, Morgan Kaufmann.
- Harrington, H.J. 1991. *Business Process Improvement: The Breakthrough Strategy for Total Quality, Productivity, and Competitiveness*, New York:, USA, McGraw-Hill.
- He P., Xu, X., and Hua, Z. 2012. „A New Method for Guiding Process Flexibility Investment: Flexibility Fit Index,” in *International Journal of Production Research* (50:14), pp. 3718-3737.
- Héam, P.C., Kouchnarenko O., and Voinot J. 2007. „Research Report of the French National Institute for Research in Computer Science and Control: Towards Formalizing QoS of Web Services with Weighted Automata,” <http://hal.inria.fr/docs/00/15/45/64/PDF/RR-6218.pdf>, March 12, 2009.
- Heinl, P., Horn, S., Jablonski, S., Neeb, J., Stein, K., and Teschke, M. 1999. „A Comprehensive Approach to Flexibility in Workflow Management Systems,” in *ACM SIGSOFT Software Engineering Notes* (24:2), pp. 79-88.
- Heinrich, B., Bewernik M., Henneberger M., Krammer A., Lautenbacher F. 2008. „SEMPA - Ein Ansatz des Semantischen Prozessmanagements zur Planung von Prozessmodellen,” in *Business and Information Systems Engineering* (50:6), pp. 445-460.
- Hepp, M. 2007. „Possible Ontologies: How Reality Constrains the Development of Relevant Ontologies,” in *IEEE Internet Computing* (11:1), pp. 90-96.
- Hepp, M., and Dumitri R. 2007 „An Ontology Framework for Semantic Business Process Management,” in *Tagungsband der 8. Internationale Tagung Wirtschaftsinformatik: eOrganisation: Service-, Prozess-, Market-Engineering*, February 2007, Karlsruhe, Germany, pp. 423-440.

-
- Hepp, M., Leymann F., Domingue J., Wahler A., and Fensel D. 2005. „Semantic Business Process Management: A Vision towards Using Semantic Web Services for Business Process Management,” *Proceedings of the IEEE International Conference on e-Business Engineering*, October 2005, Beijing, China, pp. 535-540.
- Ho, T.-H., Park, Y.-H., and Zhou, Y. P. 2006. „Incorporating Satisfaction into Customer Value Analysis: Optimal Investment in Lifetime Value,” in *Marketing Science*, (25:3), pp. 260-277.
- Huth, C., Erdmann, I., and Nastansky, L. 2001. „GroupProcess: Using Process Knowledge from the Participative Design and Practical Operation of Ad Hoc Processes for the Design of Structured Workflows,” in *Proceedings of the 34th Annual Hawaii International Conference on System Sciences*, January 2001, Maui, Hawaii.
- Iravani, S. M., van Oyen, M. P., and Sims, K. T. 2005. „Structural Flexibility: A New Perspective on the Design of Manufacturing and Service Operations,” in *Management Science* (51:2), pp. 151-166.
- Jack, E. P., and Raturi, A. 2002. „Sources of Volume Flexibility and their Impact on Performance,” in *Journal of Operations Management* (20:5), pp. 519-548.
- Johnson, M., Selnes, F. 2004. „Customer Portfolio Management: Toward a Dynamic Theory of Exchange Relationships,” in *Journal of Marketing* (68:2), pp. 1-17.
- Johnston, R., and Clark, G. 2005. *Service Operations Management: Improving Service Delivery*, Essex, UK, Prentice Hall.
- Johnston, R., Clark, G., and Shulver, M. 2012. *Service Operations Management*. London, UK, Pearson Education Limited.
- Jordan, W.C., Graves, S.C. 1995. „Principles on the Benefits of Manufacturing Process Flexibility,” in *Management Science* (41:4), pp. 577-594.
- Kaan, K., Reijers, H. A., and van der Molen, P. 2006. „Introducing Case Management: Opening Workflow Management’s Black Box,” in *Business Process Management: 4th International Conference*, September 2006, Vienna, Austria, pp. 358-367.
- Kaganer, E.; Carmel, E. Hirschheim, R., Olsen, T. 2013. „Managing the Human Cloud,” in *MIT Sloan Management Review* (54:2), pp. 23-32.

-
- Karastoyanova, D., van Lessen T., Leymann F., Ma Z., Nitzsche J., Wetzstein B., Bhiri S., Hauswirth M., and Zaremba M. 2008. „A Reference Architecture for Semantic Business Process Management Systems,” in *Tagungsband der Multikonferenz Wirtschaftsinformatik 2008*, February 2008, Munich, Germany, pp. 1727-1738.
- Keller, G., Scheer A.W. and Nuettgens M. (1992) Semantische Prozessmodellierung auf der Grundlage „Ereignisgesteuerter Prozessketten (EPK)“, in *Veröffentlichungen des Instituts für Wirtschaftsinformatik*, (89), Saarbruecken, Germany
- Knight, J. A. 1998. *Value Based Management*, New York, USA, McGraw-Hill.
- Kohlmann, F., and Alt, R. 2010. „The Impact of Service-Oriented Architecture on Business Networkability,” in *Proceedings of the 18th European Conference on Information Systems*, June 2010, Pretoria, South Africa.
- Koller, T., Goedhart, M., and Wessels, D. 1990. *Valuation: Measuring and Managing the Value of Companies*, Hoboken, USA, John Wiley and Sons.
- Kryvinska, N., Auer, L. and Strauss C. 2011. „An Approach to Extract the Business Value from SOA Services,” in *Lecture Notes in Business Information Processing: Exploring Service Science*, Heidelberg, Germany, Springer, pp. 42-52.
- Kumar, K., and Narasipuram, M. M. 2006. „Defining Requirements for Business Process Flexibility,” in *Workshop on Business Process Modeling, Design and Support, Proceedings: Requirements for Flexibility and the Ways to Achieve it., International Conference on Advanced Information Systems Engineering 06 Workshops*, June 2006, Luxembourg, pp. 137-148.
- Kumar, V., and George, M. 2007. „Measuring and Maximizing Customer Equity: A Critical Analysis,” in *Journal of the Academic Marketing Science*, (35:2), pp. 157-171.
- Kumar, V., Petersen, J., Leone, R. 2010. „Driving Profitability by Encouraging Customer Referrals: Who, When, and How,” in *Journal of Marketing*, (74:5), pp. 1-17.
- Kumar, V., Ramani, G., and Bohling, T. 2004. „Customer Lifetime Value Approaches and Best Practice Applications,” in *Journal of Marketing*, (18:3), pp. 60-72.
- Kumar, V.; Fantazy, K. A.; Kumar, U.; Boyle, T. A. 2006. „Implementation and Management Framework for Supply Chain Flexibility,” in *Journal of Enterprise Information Management* (19:3), pp.303-319.

-
- Kuropka, D., Weske M. 2008. „Implementing a Semantic Service Provision Platform - Concepts and Experiences,” in *Business and Information Systems Engineering* (50:1), pp. 16-21.
- Lee, C. F., Lee, J. C., and Lee, A. C. 2000. *Statistics for Business and Financial Economics*, Singapore, Singapore, World Scientific.
- Leimeister, J. M. 2012, *Dienstleistungsengineering und-management*, Heidelberg, Germany, Springer.
- Lillrank, P. 2003. „The Quality of Standard, Routine and Nonroutine Processes,” in *Organization Studies* (24:2), pp. 215-233.
- Luftman, J.; Zadeh, H. S.; Derksen, B.; Santana, M.; Rigoni, E. H.; Huang, Z. 2012. „Key Information Technology and Management Issues 2011-2012: an International Study,” in *Journal of Information Technology* (27:3), pp. 198-212.
- Mandelbaum, M., and Buzacott, J. A. 1990. „Flexibility and Decision Making,” in *European Journal of Operations Research* (44:1), pp. 17-27.
- Martin, J. D., Petty, J. W., and Wallace, J. S. 2009. *Value-Based Management with Corporate Social Responsibility*, Oxford, UK, Oxford University Press.
- Mascarenhas, M. 1981. „Planning for Flexibility,” in *Long Range Planning* (14:5), pp. 78-82.
- Montoya, M., Massey, A., Khatri, V. 2010. „Connecting IT Services Operations to Services Marketing Practices,” in *Journal of Management Information Systems* (26:4), pp. 65-85.
- Muenstermann, B., Eckhardt, A., and Weitzel, T. 2010. „The Performance Impact of Business Process Standardization – An Empirical Evaluation of the Recruitment Process,” in *Business Process Management Journal*, (16:1), pp. 29-56.
- Mukherjee, S. 2007. *Modern Economic Theory*, New Delhi, India, New Age International Publishers.
- Neuhuber, L., Krause, F., and Röglinger, M. 2013. „Flexibilization of Service Processes: Toward an Economic Optimization Model,” in *Proceedings the of 21st European Conference on Information Systems*, June 2013, Utrecht, The Netherlands.

-
- Nguyen, B., and Mutum, D. S. 2012. „A Review of Customer Relationship Management: Successes, Advances, Pitfalls and Futures,” in *Business Process Management Journal*, (18:3), pp. 400-419.
- OECD. 1998. „The Challenge of Measuring and Evaluating Organisational Change in Enterprises,” Paris, France, OECD.
- Oke, A. 2005. „A Framework for Analysing Manufacturing Flexibility,” in *International Journal of Operations and Production Management* (25:10), pp. 973-996.
- OMG. 2008. „Unified Modeling Language: Superstructure Version 2.1.2,“ <http://www.omg.org/technology/documents/formal/uml.htm>, accessed 2014/08/04.
- Papazoglou, M. P., and Van Den Heuvel, W.-J. 2007. „Service Oriented Architectures: Approaches, Technologies and Research Issues,” in *The VLDB journal*, (16:3), pp. 389-415.
- Pedrinaci, C., Domingue J., and Alves de Medeiros A. 2008. „A Core Ontology for Business Process Analysis,” in *Lecture Notes in Computer Science* (5021), pp 49-64.
- Pentland, B.T. 2003. „Conceptualizing and Measuring Variety in the Execution of Organizational Work Processes,” in *Management Science* (49:7), pp. 857-870.
- Phillips, R. L., 2005. *Pricing and Revenue Optimization*, Stanford, USA, Stanford University Press.
- Pinker, E. J. and Shumsky, R. A. 200. „The Efficiency-Quality Trade-Off of Cross-Trained Workers,” in *Manufacturing & Service Operations Management* (2:1), pp. 32-48.
- Pujawan, I. N. 2004. „Assessing Supply Chain Flexibility: A Conceptual Framework and Case Study,” in *International Journal of Integrated Supply Management* (1:1), pp. 79-97.
- Rai, A. and Sambamurthy, V. 2006. „Editorial Notes - The Growth of Interest in Service Management: Opportunities for Information System Scholars,” in *Information System Research*, (17:4), pp.327-331.
- Rappaport, A. 1986. *Creating Shareholder Value: The New Standard for Business Performance*, New York, USA, Free Press.

-
- Ray, S., and Jewkes, E. M. 2004. „Customer Lead Time Management: When Both Demand and Price are Lead Time Sensitive,” in *European Journal of Operational Research*, (153:3), pp. 769-781.
- Regev, G., and Wegmann, A. 2005 „A Regulation-Based View on Business Process and Supporting System Flexibility,” in *Workshop on Business Process Modeling, Design and Support: Design for Flexibility, Proceedings of the International Conference on Advanced Information Systems Engineering 05 Workshops*, June 2005, Porto, Portugal, pp. 91-98.
- Regev, G., Soffer P., Schmidt R. 2005 „Taxonomy of Flexibility in Business Processes,” in *Workshop on Business Process Modeling, Design and Support, Proceedings: Requirements for Flexibility and the Ways to Achieve it, International Conference on Advanced Information Systems Engineering 06 Workshops*, June 2006, Luxembourg, pp. 81-84.
- Reichert, M., and Weber, B. 2012. *Enabling Flexibility in Process-Aware Information Systems: Changes, Methods, Technologies*, Heidelberg, Germany, Springer.
- Ren, Z. J., and Zhou, Y.-P. 2008. „Call center outsourcing: Coordinating Staffing Level and Service Quality,” in *Management Science* (54:2), pp.369-383.
- Rosemann, M., and Recker, J. C. 2006. „Context-Aware Process Design: Exploring the Extrinsic Drivers for Process Flexibility,” in *Workshop on Business Process Modeling, Design and Support, Proceedings: Requirements for Flexibility and the Ways to Achieve it, International Conference on Advanced Information Systems Engineering 06 Workshops*, June 2006, Luxembourg, pp. 149-158.
- Rosemann, M., Recker, J. C., and Flender, C. 2008. „Contextualisation of Business Processes,” in *International Journal of Business Process Integration and Management* (3:1), pp. 47-60.
- Saleh, J. H., Mark, G., and Jordan, N. C. 2009. „Flexibility: A Multi-Disciplinary Literature Review and a Research Agenda for Designing Flexible Engineering Systems,” in *Journal of Engineering Design* (20:3), pp. 307-323.
- Sasser, W. E. 1976. „Match Supply and Demand in Service Industries,” in *Harvard Business Review* (54:6), pp. 133-140.

-
- Schober, F., and Gebauer, J. 2011. „How Much to Spend on Flexibility Determining the Value of Information System Flexibility,” in *Decision Support Systems* (51:3), pp. 638-647.
- Schonenberg, H., Mans, R. S., Russell, N. C., Mulyar, N. A., and van der Aalst, W. M. P. 2008. „Process Flexibility: A survey of Contemporary Approaches,” in *Advances in Enterprise Engineering*, Berlin, Germany, Springer, pp. 16-30.
- Sethi, A., and Sethi, S. 1990. „Flexibility in Manufacturing: A Survey,” in *International Journal of Flexible Manufacturing Systems* (2:4), pp. 289-328.
- Sidorova, A., and Isik O. 2010. „Business Process Research: A Cross-Disciplinary Review,” in *Business Process Management Journal* (16:4), pp. 566-597.
- Simperl, E.P.B., Tempich C., and Sure Y. 2006. „ONTOCOM: a cost estimation model for ontology engineering,” in *Proceedings of the 5th International Semantic Web Conference*, November 2006, Athens, USA, pp. 625-639.
- Snowdon, R., Warboys, B., Greenwood, R., Holland, C., Kawalek, P., and Shaw, D. 2007. „On the Architecture and Form of Flexible Process Support,” in *Software Process Improvement and Practice* (12:1), pp. 21-34.
- Soffer, P. 2005. „On the Notion of Flexibility in Business Processes,” in *Workshop on Business Process Modeling, Design and Support: Design for Flexibility, Proceedings of the International Conference on Advanced Information Systems Engineering 05 Workshops, June 2005, Porto, Portugal*, pp. 35-42.
- Steen, M. W. A., Strating, P., Lankhorst, M. M., ter Doest, H., and Iacob, M. E. 2005. „Service-Oriented Enterprise Architecture,” in *Service-Oriented Software System Engineering: Challenges and Practices*, Hershey, USA, Idea Group Publishing, pp. 132-154.
- Stewart, G. B., and Stern, J. M. 1991. *The Quest for Value: The EVA Management Guide*, New York, USA, HarperBusiness.
- Suarez, F. F., Cusumano, M. A., and Fine, C. H. 1996. „An Empirical Study of Manufacturing Flexibility in Printed Circuit Board Assembly,” in *Operations Research* (44:1), pp. 223-240.

-
- Tannous, G. F. 1996. „Capital Budgeting for Volume Flexible Equipment,” in *Decision Science*, (27:2), pp. 157-184.
- Tanrisever, F., Morrice, D., and Morton, D. 2012. „Managing Capacity Flexibility in Make-to-Order Production Environments,” in *European Journal of Operational Research* (216:2), pp.334-345.
- Taudes, A., Feurstein, M., and Mild, A. 2000. „Options Analysis of Software Platform Decisions: A Case Study,” in *MIS Quarterly*, (24:2), pp. 227-243.
- Teramoto, Y., Richter, F.-J., Iwasaki, N., Takai, T., and Wakuta, Y. 2012. „Global Strategy in the Japanese Semiconductor Industry: Knowledge Creation Through Strategic Alliances,” in *Japanese Multinationals: Strategies and Management in the Global Kaisha*, London, UK, Routledge, pp. 71-84.
- Trigeorgis, L. 1996. *Real Options: Management Flexibility and Strategy in Resource Allocation*, Cambridge, UK. MIT Press.
- Trkman, P. 2010. „The Critical Success Factors of Business Process Management,” in *International Journal of Information Management* (30:2), pp. 125-134.
- Ullrich, C. 2013. „Valuation of IT Investments Using Real Options Theory,” in *Business & Information Systems Engineering*, (5:5), pp. 331-341.
- Upton, D. M. 1995. „Flexibility as Process Mobility: The Management of Plant Capabilities for Quick Response Manufacturing,” in *Journal of Operations Management* (12:3), pp. 205-224.
- van Biesebroeck, J. 2007. „The Cost of Flexibility,” *Assembly Automation* (27:1), pp. 55-64.
- van der Aalst, W. M. P. 2013. „Business Process Management: A Comprehensive Survey,” in *ISRN Software Engineering*.
- van der Aalst, W.M.P., Günther C., Recker J., and Reichert M. 2006. „Using Process Mining to Analyze and Improve Process Flexibility,” in *Workshop on Business Process Modeling, Design and Support, Proceedings: Requirements for Flexibility and the Ways to Achieve it, International Conference on Advanced Information Systems Engineering 06 Workshops*, June 2006, Luxembourg, pp. 168-177.
- Van Jaarsveld, D., Kwon, H., and Frost, A. 2009. „The Effects of Institutional and Organizational Characteristics on Work Force Flexibility: Evidence from Call Centers

- in Three Liberal Market Economies,” in *Industrial and Labor Relations Review*, (62:4), pp. 573-601.
- Verhoef C. 2002. „Quantitative IT Portfolio Management,” in *Science of Computer Programming* (45:1), pp. 1-96.
- Vom Brocke, J., Becker J., Maria Braccini A., Butleris R., Hofreiter B., Kapočius K., De Marco M., Schmidt G., Seidel S., and Simons A. 2011. „Current and Future Issues in BPM Research: A European Perspective from the ERCIS Meeting 2010,” in *Communications of the Association for Information Systems* (28:1) pp. 394-414.
- Vom Brocke, J., Recker J., and Mendling J. 2010. „Value-Oriented Process Modeling: Integrating Financial Perspectives into Business Process Redesign,” in *Business Process Management Journal* (16:2), pp. 333-356.
- Vouk, M. A. 2008. „Cloud Computing—Issues, Research and Implementations,” in *Journal of Computing and Information Technology*, (16:4), pp. 235-246.
- Wagner, D., Suchan, C., Leunig, F., and Frank, J. 2011a. „Towards the Analysis of Information Systems Flexibility: Proposition of a Method,” in *Proceedings of the 10th International Conference on Wirtschaftsinformatik*, February 2011, Zurich, Swiss, pp. 808-817.
- Wagner, D., Leunig, B., Suchan, C. Frank, J., and Ferstl O. K. 2011b. „Klassifikation von Geschäftsprozessen anhand ihres Flexibilitätsbedarfs,” in *Dienstorientierte IT-Systeme für hochflexible Geschäftsprozesse*, Bamberg, Germany, University of Bamberg Press, pp. 53-78.
- Wang, T., and De Neufville, R. 2005. „Real Options “in” Projects,” in *9th Real Options Annual International Conference*, June 2005, Paris, France.
- Weber, B., Reichert, M., and Rinderle-Ma, S. 2008. „Change Patterns and Change Support Features – Enhancing Flexibility in Process-Aware Information Systems,” in *Data and Knowledge Engineering*, (66:3), pp. 438-466.
- Whitt, W. 2006. „Staffing a Call Center with Uncertain Arrival Rate and Absenteeism,” in *Production and Operations Management*, (15:1), pp. 88-102.

-
- Wynn, M.T., Verbeek H., van der Aalst W.M.P., ter Hofstede A.H.M., and Edmond D. 2009. „Business process verification - finally a reality!“, in *Business Process Management Journal* (15:1), pp. 74-92.
- Zapf, I.: Flexibilität am Arbeitsmarkt durch Überstunden und Arbeitszeitkonten: Messkonzepte, Datenquellen und Ergebnisse im Kontext der IAB-Arbeitszeitrechnung. IAB Forschungsbericht (2012).
- Zelenoic, D. M. 1982. „Flexibility - A Condition for Effective Production Systems,“ in *The International Journal of Production Research* (20:3), pp. 319-337.
- Zhang, F., Roundy, R., Cakanyildirim, M., and Huh, W. T. 2004. „Optimal Capacity Expansion for Multi-Product, Multi-Machine Manufacturing Systems with Stochastic Demand,“ in *IIE Transactions* (36:1), pp. 23-36.

IV Ergebnisse und Ausblick

In diesem Kapitel werden in Abschnitt IV.1 zunächst die wesentlichen Erkenntnisse dieser Dissertationsschrift zusammengefasst und anschließend in Abschnitt IV.2 mögliche Anknüpfungspunkte für die weitere Forschung vorgestellt.

IV.1 Ergebnisse

Das Ziel dieser Dissertationsschrift war es, einen Beitrag zur ökonomisch sinnvollen Steigerung der Prozessflexibilität zu leisten. Hierzu wurde zunächst diskutiert, welche Bedarfstreiber der Prozessflexibilität existieren, wie unterschiedliche Definitionen der Prozessflexibilität mithilfe dieser Bedarfstreiber strukturiert werden können und welche Maßnahmen zur Steigerung der Prozessflexibilität zur Verfügung stehen (Kapitel II). Anschließend wurde die ökonomische Bewertung von verschiedenen Maßnahmen zur Prozessflexibilitätssteigerung detailliert betrachtet (Kapitel III). Dabei wurde insbesondere im Dienstleistungsbereich der Zusammenhang zwischen Investitionen in Flexibilität und der total service time, der Effekt von flexiblen Kapazitäten zwischen Prozessen auf die Volumenflexibilität sowie die Möglichkeit der Einbindung eines externen Dienstleisters in die unternehmenseigenen Prozesse untersucht. Darüber hinaus wurde automatisiertes Prozess-Redesign als Maßnahme zur Steigerung der inhaltlichen Flexibilität analysiert. Dabei wurden bei der Bewertung aller Maßnahmen die notwendigen Investitionen sowie die laufenden Ein- und Auszahlungen berücksichtigt, um Entscheidungen zur aus ökonomischer Sicht optimalen Investitionshöhe für Prozessflexibilität oder zur Festlegung des aus ökonomischer Sicht optimalen Prozessflexibilitätsgrades treffen zu können. Im Folgenden werden die zentralen Ergebnisse der Dissertationsschrift noch einmal separat für jeden Abschnitt dargestellt:

- In Kapitel II wurden basierend auf den konstitutiven Eigenschaften von Dienstleistungen Bedarfstreiber für die Prozessflexibilität von Dienstleistern abgeleitet. Diese Bedarfstreiber bieten einen sinnvollen Rahmen, um zahlreiche in der Wissenschaft und Praxis existierende Definitionen von Prozessflexibilität zu strukturieren. Im Anschluss wurden unterschiedliche Maßnahmen vorgestellt, die zur Steigerung von Prozessflexibilität beitragen können. Hierbei wurden vier Bedarfstreiber der Prozessflexibilität identifiziert, die durch unterschiedliche Maßnahmen adressiert werden können. Im Rahmen des Bedarfstreibers „Schwankende Nachfrage nach bestehenden Dienstleistungen“ können hohe Automatisierung, die Einführung und Konfiguration von Zeitarbeit und

Arbeitszeitkonten, Multi-Skilling sowie die Einbindung von Kunden in den Prozessablauf zur Steigerung der Prozessflexibilität beitragen. Der Bedarfstreiber „Änderungen in der Leistungserbringung bestehender Dienstleistungen“ hingegen kann mithilfe von umfangreichen Alternativen im Prozessmodell, temporären Abweichungsoptionen von Prozessinstanzen, der Möglichkeit von dauerhaften Änderungen des Prozessmodells sowie der bewussten Unterspezifikation des Prozessmodells adressiert werden. Im Gegensatz dazu kann die Prozessflexibilität mit dem Ziel, „Neue oder veränderte Dienstleistungen“ zu generieren durch Modularisierung und Standardisierung sowie durch den gezielten Einsatz von neuen Technologien gesteigert werden. Der vierte identifizierte Bedarfstreiber „Änderungen bei eingebundenen Partnern“ nimmt dabei eine Sonderposition ein, da Prozessflexibilität in diesem Bereich einerseits durch Einbindung von mehreren externen Partnern („Multi-Sourcing“) gesteigert werden kann, andererseits die den vorherigen Bedarfstreibern zugeordneten Maßnahmen auch bei den eingebundenen Partnern umgesetzt werden können.

- Ziel von Kapitel III war es, Maßnahmen zur Steigerung der Prozessflexibilität unter ökonomischen Aspekten bewerten zu können. Dazu wurde in Beitrag 2 ein Modell entwickelt, das den Einfluss von Flexibilitätsprojekten auf Dienstleistungsprozesse darstellt. Im Modell wurden sowohl positive als auch negative monetäre Effekte der Prozessflexibilität berücksichtigt und sowohl Volumenflexibilität als auch inhaltliche Flexibilität betrachtet. Dabei wurde insbesondere Wert auf die positiven monetären Effekte gelegt. Das Modell basiert auf der Annahme, dass Investition in Prozessflexibilität die „total service time“ (die Zeit ab der Serviceanfrage eines Kunden bis zu deren vollständiger Bearbeitung) eines Dienstleistungsprozesses verkürzen zu können. Dabei zeigte sich, dass Maßnahmen zur Steigerung der Volumenflexibilität die total service time für alle Kundengruppen reduzieren können, während Maßnahmen zur Steigerung der inhaltlichen Flexibilität insbesondere die Vorbereitungszeit (setup time) des Dienstleistungsprozesses verkürzen können und so nur diejenigen Kundengruppen betreffen, welche Services anfragen, die nicht im Standardrepertoire des Dienstleisters enthalten sind. Weiterhin wurden das für die Umsetzung der Flexibilitätsmaßnahmen notwendige Investitionsvolumen im Modell berücksichtigt. Kennt ein Unternehmen durch Marketingstudien die Zusammensetzung seiner Kundengruppen, erlaubt das Modell damit, die aus ökonomischer Sicht optimale Auswahl an Projekten zur Verbesserung der Volumenflexibilität oder der Inhaltsflexibilität zu treffen.

In Beitrag 3 wurden dagegen flexible Kapazitäten als eine konkrete Maßnahme der Steigerung von Prozessflexibilität betrachtet. Indem im Beitrag untersucht wurde, ob und wieviel Kapazität eines Prozesses einem anderen Prozess zur Verfügung gestellt wird, erlaubte das Modell die Betrachtung von Effekten der Prozessflexibilität, die mehrere Prozesse betreffen. Das Modell betrachtete einerseits die zur Verfügung gestellte Flexibilität und andererseits die tatsächlich genutzte Flexibilität. Letztere ist abhängig von den tatsächlich eintretenden Nachfragemengen nach dem Output der jeweiligen Prozesse. So wurden verschiedene Situationen erfasst, in denen sich die zur Verfügung gestellte Flexibilität lohnen kann, da freie Kapazität vorhanden ist oder Kapazität eines Prozesses zu einem anderen Prozess mit höherer Marge reallokiert werden kann. Abhängig von der Nachfragerealisation nach den unterschiedlichen Prozessoutputs kann jedoch ebenso zu viel Flexibilität zur Verfügung gestellt werden, was dann auftritt, wenn ein hochmargiger Prozess selbst stark nachgefragt wird und ein Wegnahme von Kapazität immer zu hohen Opportunitätskosten führen würde. Durch die Kombination dieser unterschiedlichen Situationen mit den Charakteristika Kritikalität, Variabilität und Ähnlichkeit der betrachteten Prozesse erlaubte das Modell so die Betrachtung einer bislang nicht ausreichend bearbeiteten Forschungslücke: Eine wertorientierte Bewertung von Investitionen zur Steigerung der inter-prozessualen Flexibilität unter Berücksichtigung der zugrunde liegenden Prozesscharakteristika.

Die IT-gestützte Einbindung eines externen Dienstleisters bei hoher Nachfrage als weitere Maßnahme zur Steigerung der Volumenflexibilität wurde in Beitrag 4 untersucht. Dabei wurde ein Dienstleistungsprozess betrachtet, der mit unsicherer Nachfrage konfrontiert ist. Es wurde dabei davon ausgegangen, dass das Unternehmen seine internen Kapazitäten bereits so gewählt hat, dass diese im Erwartungswert die Nachfrage in einer für Kunden angemessenen total service time bedienen kann. Aufgrund der Unsicherheit der Nachfrageentwicklung kann es in Zeiten sehr hoher Nachfrage zu einer sehr hohen total service time kommen. Während in der gängigen Literatur (insbesondere aus dem Produktions- und Outsourcing Kontext) die Reduktion von Warteschlangen bereits detailliert analysiert wurde, wurden zwei Aspekte bislang nicht integriert betrachtet: a) welche Auswirkungen hat die verlängerte total service time auf den Kunden respektive den Kundenwert (Customer Equity)? und b) welcher Anteil der Serviceanfragen sollte an den externen Dienstleister ausgelagert werden? Dienstleister stehen somit vor der Entscheidung, Serviceanfragen selbst zu bearbeiten und unter Umständen negative Kundeneffekte in Kauf

zu nehmen oder einen externen Dienstleister einzubinden, welcher die Serviceanfragen zu höheren Kosten bearbeitet als dem Unternehmen bei einer internen Bearbeitung entstehen würden. Der Beitrag näherte sich dieser Fragestellung mithilfe des Realoptionsansatzes und beantwortete die Frage, wie hoch der ökonomische Wert der durch eine IT-gestützte Einbindung eines externen Dienstleisters gewonnenen Flexibilität ist. Der Realoptionsansatz war dabei in der Lage, den Kern von Flexibilität zu adressieren: Die Fähigkeit, auf unsichere zukünftige Ereignisse reagieren zu können.

Im Gegensatz zu den beiden letztgenannten Maßnahmen stellt die Möglichkeit eines automatisierten Prozess-Redesigns eine Methode dar, mit der die inhaltliche Flexibilität eines Unternehmens gesteigert werden kann. Beitrag 5 hatte zum Ziel, diese Methode mit manuellem Prozess-Redesign zu vergleichen und darauf basierend eine Obergrenze für Investitionen in automatisiertes Prozess-Redesign zu identifizieren. Im Beitrag zeigte sich, dass automatisiertes Redesign die variablen Auszahlungen für Redesign-Projekte im Vergleich zur manuellen Alternative senken kann, jedoch hohe Anfangsinvestitionen erfordert. Sind diese jedoch einmal getätigt, können mehr Projekte zum Prozess-Redesign umgesetzt werden als mit der manuellen Alternative und damit die Qualität der Prozesslandschaft weiter gesteigert werden. Somit stehen Entscheider im Unternehmen vor der Herausforderung, die Anzahl und den Umfang der anstehenden Redesign-Projekte genau abzuschätzen, um so zu identifizieren, wieviel maximal in automatisiertes Redesign investiert werden sollte. Unternehmen, deren Prozesse häufig angepasst werden, sollten damit eher in diese neue Maßnahme zur Flexibilitätssteigerung investieren.

IV.2 Ausblick

Aus den Limitationen der in dieser Dissertationsschrift enthaltenen Beiträge ergeben sich weiterführende Fragestellungen, welche zukünftigen Forschungsbedarf mit sich bringen.

In Kapitel II zeigt sich im Rahmen der Strukturierung der Prozessflexibilitätsdimensionen sowie in der Zuordnung von passenden Maßnahmen zur Steigerung der Prozessflexibilität folgender Forschungsbedarf:

1. Obwohl in Beitrag 1 unterschiedliche Maßnahmen zur Steigerung der Prozessflexibilität aufgezeigt werden, kann diese Auflistung nicht als vollständig gelten, da auch Maßnahmen aus anderen Forschungsbereichen Auswirkungen auf Prozessflexibilität haben können. So können Maßnahmen aus dem Innovationsmanagement dabei helfen, schneller neuere

Produkte oder Dienstleistungen zu generieren oder neue Erkenntnisse aus der Produktionstheorie helfen, mit schwankenden Nachfragemengen umzugehen. Daher sollte zukünftige Forschung insbesondere die Schnittstellen zu anderen Disziplinen beleuchten und deren Auswirkung auf die Prozessflexibilität eines Unternehmens darstellen.

Auf Basis von Kapitel III lassen sich hinsichtlich der Bewertung von Prozessflexibilität folgende Fragestellungen für zukünftige Forschungsarbeiten ableiten:

2. Beitrag 2 beschränkt sich auf eine einperiodige Betrachtung unter Vernachlässigung von Risikofaktoren. Um die Bewertung von Prozessflexibilitätsprojekten unter dem Paradigma der wertorientierten Unternehmensführung zu ermöglichen, sollte zukünftige Forschung mehrere Perioden analysieren sowie Risiko beispielsweise mithilfe von stochastischen Barwerten der Zahlungsströme mit einbezogen werden. Weiterhin wurden die Wirkungszusammenhänge in Bezug auf einen einzigen Prozess erarbeitet und analysiert. Diese Betrachtung könnte erweitert werden, um auch mehrere Prozesse und deren Abhängigkeiten zu berücksichtigen.
3. Um das komplexe Problemfeld von inter-prozessualer Flexibilität zu strukturieren und eine geschlossene Lösung für das Optimierungsmodell zu berechnen, waren in Beitrag 3 vereinfachende Annahmen notwendig. Diese Annahmen limitieren die Anwendung des Modells auf zwei Prozesse. Weiterhin wurde für die eingehende Kundennachfrage eine Gleichverteilung angenommen. Diese Beschränkungen könnten in zukünftiger Forschung aufgelöst werden, indem das Modell auf beliebig viele Prozesse sowie unterschiedliche Verteilungen, wie beispielsweise die Normalverteilung, angewendet wird.
4. Die Analyse einer IT-gestützten Einbindung eines externen Dienstleisters aus Beitrag 4 unterlag ebenfalls einigen Vereinfachungen, die ebenfalls Raum für zukünftige Forschung bieten. So wurde der Wert der IT-gestützten Einbindung anhand von nur einem einzigen Auslagerungszeitpunkt bestimmt. Obwohl diese pessimistische Betrachtung eine kurz- bis mittelfristige Bewertung erlaubt, ist es wahrscheinlich, dass Überschussnachfrage nach erfolgreicher Einbindung eines externen Dienstleisters mehrmals an diesen abgegeben wird. Eine entsprechende Erweiterung des Modells würde auch diese langfristige Perspektive berücksichtigen. Weiterhin stellt die Analyse von negativen monetären Effekten durch unzufriedene Kunden zwar einen ersten Schritt in der Verbindung des Customer Relationship Managements und der Flexibilitätsforschung dar, dennoch sind diese Effekte in zukünftiger Forschung noch detaillierter zu berücksichtigen. So könnten beispielsweise

„Word of Mouth“-Effekte oder Abhängigkeiten zwischen den einzelnen Kundenerfahrungen explizit modelliert werden.

5. Im Rahmen der Analyse von automatisiertem Prozess-Redesign fokussierte sich Beitrag 5 auf die Auszahlungsseite und nahm an, dass manuelles Prozess-Redesign zu den gleichen Ergebnissen wie die automatisierte Alternative führt. Die Betrachtung der Einzahlungsseite dieser neuen Technologie bietet ein breites Feld an Möglichkeiten für weitere Forschung. So könnte beispielsweise betrachtet werden, ob durch automatisiertes Prozess-Redesign bessere Ergebnisse erreicht werden können und damit die Qualität der Prozesse im Unternehmen angehoben werden. Ein weiterer Vorteil könnte eine frühere time-to-market sein, so dass Unternehmen hierdurch Wettbewerbsvorteile gegenüber Konkurrenten erzielen könnten. Zudem befindet sich die neue Technologie noch in den Kinderschuhen und es existieren wenige voll funktionale Prototypen. Deren Erstellung stellt ein eigenes Forschungsfeld dar, in dem zahlreiche unbeantwortete Fragen liegen (z.B. wie Parallelisierungen in Prozessmodellen korrekt und vollständig erkannt werden können).

Zusammengenommen wurden in dieser Dissertation ausgewählte Fragestellungen im Bereich der Prozessflexibilität bearbeitet, wobei ein besonderer Fokus auf der Bewertung von Maßnahmen zur Steigerung der Prozessflexibilität lag. Obwohl damit wichtige Fragen beantwortet werden konnten, bleibt das Thema Prozessflexibilität auch in den nächsten Jahren hochrelevant für Wissenschaft und Praxis. Aufgrund der sich immer schneller ändernden Unternehmensumwelt und neu auftretender Maßnahmen zur Prozessflexibilisierung ist es von enormer Bedeutung, diese Instrumente in ihrer Wirkungsweise und insbesondere in ihren ökonomischen Effekten zu verstehen und zu analysieren. Es wäre wünschenswert, wenn die damit verbundene zukünftige Forschung etwas von Ideen und Erkenntnissen dieser Dissertationsschrift profitieren könnte.