Economic Perspectives on 3D Printing

Von der Fakultät für Wirtschaftswissenschaften der Rheinisch-Westfälischen Technischen
Hochschule Aachen zur Erlangung des akademischen Grades eines Doktors der
Wirtschafts- und Sozialwissenschaften genehmigte Dissertationn

vorgelegt von

Christian Weller

Berichter: Prof. Dr. Frank T. Piller

Prof. Dr. Daniel Wentzel

Diese Dissertation ist auf den Internetseiten der Universitätsbibliothek online verfügbar

Table of Contents

Zusammenfassung	III
Executive Summary	VI
Thesis Structure Overview	
Table of Contents	X
List of Figures	XIII
List of Tables	XV
List of Abbreviations	
Part A. Introduction to the Research Field	1
1 Introduction	
1.1 Motivation	
1.2 Goal of the Thesis	6
1.3 Outline of Research Project	
2 AM Technology and Industry Overview	11
2.1 Technology Landscape	
2.2 Industry Overview and Applications	
2.3 AM Ecosystem	21
2.4 Excerpt: AM Technology from a User Innovation Perspective	24
3 Product Demand Heterogeneity & Approaches to Customization	27
3.1 The Long Tail of Product Demand	27
3.2 Why Customers Demand Customized Products	29
3.3 Fulfilling Demand Heterogeneity with Customization Strategies	32
4 Research Questions and Corresponding Research Papers	37
4.1 Research Questions and Research Paper Overview	37
4.2 Summaries of the Research Papers	41
4.2.1 Research Paper I: "Economic Implications of 3D Printing: Market Structure Model Additive Manufacturing Revisited"	
4.2.2 Research Paper II: "The Value of Higher Co-Design Freedom: Product Customizate Printing"	
4.2.3 Research Paper III: "Product Customization with 3D Printing: Perceived Product V	
5 Discussion and Conclusion	46
5.1 Theoretical Implications	46
5.2 Managerial Implications	48
5.3 Limitations and Future Research	
5.4 Conclusion	53
References	56
Part B. Research Papers I-III	64
Research Paper I: Economic Implications of 3D Printing: Market Structure Models in Light Manufacturing Revisited	of Additive
I Abstract	66
I.1 Introduction	67
I.2 AM Characteristics and Key Principles for Manufacturing Firms	70

I.2.1 Technological Background of AM	70
1.2.2 Economic Characteristics of AM	<i>7</i> 4
I.2.3 AM's Key Principles for Manufacturing Firms	78
I.3 AM's Impact on a Manufacturing Firm's Payoff Function	79
I.3.1 Payoff Function as Defined by Milgrom & Roberts (1990)	80
1.3.2 AM's Key Principles Applied to the Payoff Function	81
I.4 FMS and market structure	86
1.4.1 Overview	86
1.4.2 Product Attribute Address Models	89
I.4.3 Game-Theoretic Models for Technology Choice	91
I.5 Impact of AM on Market Structure Models	93
I.5.1 Product Attribute Address Models & AM	93
I.5.2 Game-Theoretic Models for Technology Choice & AM	98
I.6 Conclusion and Implications for Future Research	101
I References	107
Research Paper II: The Value of Higher Co-Design Freedom: Product Customization with 3D Printing.	113
II. Abstract	
II.1 Introduction and Motivation	
II.2 Literature Review and Hypotheses Development: Value Creation with "Full Customization"	
II.2.1 Product Customization as a Means to Address the Long Tail of Product Demand	
II.2.2 Customer Benefits Derived from Customization	
II.3 Research Design and Method: Consumer Experiments with Different Degrees of I Customizability	
II.3.1 Study Design & Procedure	126
II.3.2 Measurement	128
II.4 Analysis	130
II.4.1 Study 1: Is There a Value Increment for Full Customization of Products? A Simulated Process	, ,
II.4.2 Study 2: How Can The Value Increment of Full Customization Be Explained? Con Experiments with Binding WTP	
II.5 Discussion and Implications	141
II.5.1 Overall Discussion	141
II.5.2 Theoretical Implications	143
II.5.3 Managerial Implications	145
II.6 Limitations and Future Research	146
II.A Appendix	149
II.A. 1 Scales	149
II.A.2 Treatments	151
II.A.3 Examples of Self-Designed Espresso Cups in Study 2	154
II.A.4 Experiment Description for Study 2 (in German)	155
II References	158
Research Paper III: Product Customization with 3D Printing: Perceived Product Value and Its Drivers	165
III Abstract	165
III.1 Introduction and Motivation	166

III.2 Literature Review and Hypotheses Development: Value Creation with Customized Products in Light of Additive Manufacturing
III.2.1 Customer Benefits Derived from Customization
III.2.2 Technology Hype and Novelty Effect
III.3 Research Design and Method: Consumer Experiments with Different Degrees of Product Customization
III.3.1 Study Design & Procedure
III.3.2 Measurement
III.4 Analysis
III.4.1 Study 1: Product Value of Customizable Products with Focus on Style-Related (Aesthetic) Attributes
III.4.2 Study 2: Product Value of Customizable Products with Focus on Fit-Related Product Parameters
III.5 Discussion and Implications
III.5.1 Overall Discussion
III.5.2 Theoretical Implications
III.5.3 Managerial Implications
III.6 Limitations and Future Research
III.A Appendix
III.A.1 Scales
III.A.2 Treatments
III.A.3 Regression Models (DV: Delta WTP)
III References