## Volker Simmering

## The Evolution of Standards

With a Foreword by Prof. Dr. Manfred J. Holler

| Table of Contents |  |
|-------------------|--|
|-------------------|--|

XI

## **Table of Contents**

| 1.                                                                                                   | Intr                                                                                                      | oduction          |                 |             | ,              |               | 1        |
|------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------|-------------------|-----------------|-------------|----------------|---------------|----------|
| 2.                                                                                                   | The Economics of Networks, Compatibility and Standardization:<br>Definitions, Basic Concepts and Insights |                   |                 |             |                | 7             |          |
|                                                                                                      | 2.1                                                                                                       | The               | Concept         | of          | Network        | Effects       | 7        |
|                                                                                                      | 2.2                                                                                                       | Basic Pro         | blems in        | Competit    | ive Network    | Markets       | 11       |
|                                                                                                      | 2.3                                                                                                       | Compatibility,    | Standardizati   | on, Harn    | ionization and | l Integration | 16       |
|                                                                                                      | 2.4                                                                                                       | Commitments       |                 |             |                |               | 20       |
|                                                                                                      | 2.5                                                                                                       | Compatibility as  | nd Competition  | ı           |                |               | 22       |
|                                                                                                      | 2.6                                                                                                       | Empirical         | Evidence        | of          | Network        | Effects       | 29       |
| 3.                                                                                                   | An                                                                                                        | Evolutionary A    | approach to N   | etwork E    | ffects and Glo | balization    | 32       |
|                                                                                                      | 3.1                                                                                                       | Introduction      |                 |             |                |               | 32       |
|                                                                                                      | 3.2                                                                                                       | Review            | of              | Selec       | ted Lit        | erature       | 33       |
|                                                                                                      | 3.3                                                                                                       | The Model Setup   |                 |             |                |               | 35       |
|                                                                                                      |                                                                                                           | 3.3.1 Populations | <b>.</b>        |             | •              | •             | 35       |
|                                                                                                      |                                                                                                           | 3.3.2 Interaction | Games           |             |                |               | 36       |
|                                                                                                      |                                                                                                           | 3.3.3 Integration |                 |             |                |               | 37       |
|                                                                                                      | 2.4                                                                                                       | 3.3.4 Fitness     | .7.7            |             |                |               | 39       |
|                                                                                                      | 3.4 Existence of Equilibria 3.4.1 Isolated Populations (OD=0)                                             |                   |                 |             |                | 43            |          |
|                                                                                                      |                                                                                                           |                   |                 | <b>(</b> 1) |                |               | 43<br>45 |
| 3.4.2 Integrated Populations (l <to<0) 3.4.3="" harmonization<="" td=""><td></td><td>46</td></to<0)> |                                                                                                           |                   |                 |             |                | 46            |          |
|                                                                                                      |                                                                                                           | 3.4.4 Variety     |                 |             |                |               | 46       |
|                                                                                                      | 3.5                                                                                                       | ·                 | Social          |             | Welfare        |               | 47       |
| 3.5.1 Welfare With Harmonization                                                                     |                                                                                                           |                   |                 | 48          |                |               |          |
| 3.5.2 Efficiency of Variety and Harmonization                                                        |                                                                                                           |                   |                 |             |                | 48            |          |
|                                                                                                      | 3.6                                                                                                       | Does Globaliza    | tion Lead to    | Efficient 1 | Harmonization  | of Standards  | 50       |
|                                                                                                      | 3.7                                                                                                       | Some              | Interpretations | s of        | the As         | ssumptions    | 53       |
|                                                                                                      |                                                                                                           | 3.7.1 Darwinian   |                 |             |                |               | 53       |
|                                                                                                      |                                                                                                           | 3.7.2 Conditional | l Strategies    |             |                |               | 54       |

| XII | Table | of | Contents |
|-----|-------|----|----------|
|     |       |    |          |

|    | 3.8                                                |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | 56<br>56<br>58<br>60<br>63 |  |  |  |
|----|----------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------|--|--|--|
| 4. | Ma                                                 | ndatory or Voluntary Standards?                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | 65                         |  |  |  |
|    | 4.1                                                | Introduction                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | 65                         |  |  |  |
|    | 4.2                                                | The Effects of Mandatory and Voluntary Standards                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | 66                         |  |  |  |
|    |                                                    | 4.2.1 Inducing a Collective Switch through Voluntary Standards                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | 66                         |  |  |  |
|    |                                                    | 4.2.2 Changing Interaction Payoffs through Mandatory Standards                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | 69                         |  |  |  |
|    |                                                    | 4.2.3 Which Kind of Standard is Optimal?                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | 70                         |  |  |  |
|    | 4.3                                                | The Stability of Variety                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | 71                         |  |  |  |
|    |                                                    | <ul><li>4.3.1 Formal Expressions . &lt;</li><li>4.3.2 Variety's Stability and the Integration Level</li></ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | 71<br>72                   |  |  |  |
|    |                                                    | 4.3.2 Variety's Stability and the Agents' Preferences                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | 73                         |  |  |  |
|    |                                                    | 4.3.4 Variety's Stability and the Populations' Sizes                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | 74                         |  |  |  |
|    |                                                    | 4.3.5 Variety's Stability and Efficiency of the Global Standards                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | 75                         |  |  |  |
|    | 4.4                                                | Technical Harmonization within the EU                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | 76                         |  |  |  |
|    |                                                    | 4.4.1 The Process of Technical Harmonization in Europe                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | 77                         |  |  |  |
|    |                                                    | 4.4.2 How European Standards Produce Harmonization                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | 79                         |  |  |  |
|    |                                                    | 4.4.3 Results                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | 83                         |  |  |  |
|    | 4.5                                                | Conclusions                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | 86                         |  |  |  |
| 5. |                                                    | e Impact of Users' Commitments on Technological Progress in<br>work Industries                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | 88                         |  |  |  |
|    | 5.1                                                | Introduction                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | 88                         |  |  |  |
|    |                                                    | 5.1.1 Link to the Evolutionary Model in Section 3                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | 88                         |  |  |  |
|    |                                                    | 5.1.2 Summary of the Model                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | 89                         |  |  |  |
|    | 5.2                                                | Review of Selected Literature                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | 92                         |  |  |  |
|    |                                                    | 5.2.1 Modeling Dynamic Demand                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | 93                         |  |  |  |
|    |                                                    | 5.2.2 A Brief Note on Sponsored vs. Non-Sponsored Technologies                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | 99                         |  |  |  |
|    |                                                    | - Control of the cont | 102                        |  |  |  |
|    | 5.4                                                | 1                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | 105                        |  |  |  |
|    |                                                    | 1 1                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | 106<br>116                 |  |  |  |
|    | 5.4.2 Equilibria With Strong Commitments(Ci > C\") |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                            |  |  |  |

|    |                                                                                                                                                                                                                                                                                   |                          | Table             | of              | Conter               | nts                                     | XIII |
|----|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------|-------------------|-----------------|----------------------|-----------------------------------------|------|
|    | 5.4.3 Equilibria With Weak Commitments (d $< C \setminus^H$ )<br>5.4.4 Summary of Plausible Nash Equilibria                                                                                                                                                                       |                          |                   |                 | 122<br>130           |                                         |      |
|    | 5.5 Welfare Analysis - Commitments and Efficiency of Transition 5.5.1 Strong Commitments: Excess Momentum and Excess Inertia 5.5.2 Weak Commitments: Excess Momentum and Excess Inertia 5.5.3 Summary of Excess Momentum and Excess Inertia 5.5.4 Commitments and Transition Time |                          |                   |                 |                      | 131<br>134<br>142<br>149<br>151         |      |
|    | 5.6                                                                                                                                                                                                                                                                               | Should                   | Poli              | cy              | Intervene?           |                                         | 157  |
|    | 5.7                                                                                                                                                                                                                                                                               | Conclusions              |                   | •               |                      |                                         | 161  |
|    | App                                                                                                                                                                                                                                                                               | endix                    |                   | A               |                      |                                         | 163  |
|    |                                                                                                                                                                                                                                                                                   | endix                    |                   | В               |                      |                                         | 165  |
|    |                                                                                                                                                                                                                                                                                   |                          |                   |                 |                      |                                         |      |
| 6. | Vot                                                                                                                                                                                                                                                                               | ing on Harmonizatio      |                   |                 |                      |                                         | 166  |
|    | 61                                                                                                                                                                                                                                                                                | Introduction             | i                 |                 |                      |                                         | 166  |
|    | 6.2                                                                                                                                                                                                                                                                               |                          | Vertical          | and Horiza      | ontal Com            | patibility                              | 168  |
|    | ٠                                                                                                                                                                                                                                                                                 | 6.2.1 The Mix and Mat    |                   | 110112,0        |                      | , , , , , , , , , , , , , , , , , , , , | 168  |
|    |                                                                                                                                                                                                                                                                                   | 6.2.2 Incentives to Prod | -                 | Compatibility   |                      |                                         | 169  |
|    |                                                                                                                                                                                                                                                                                   | 6.2.3 Horizontal Compa   | atibility and the | e Benefits of H | <b>Iarmonization</b> |                                         | 170  |
|    | 6.3                                                                                                                                                                                                                                                                               | Majority Voting and      | Harmonizatio      | on              |                      |                                         | 172  |
|    |                                                                                                                                                                                                                                                                                   | 6.3.1 Majority Voting i  |                   | on Bodies       |                      |                                         | 172  |
|    |                                                                                                                                                                                                                                                                                   | 6.3.2 The Voting Mode    |                   |                 |                      |                                         | 173  |
|    |                                                                                                                                                                                                                                                                                   | 6.3.3 Are Outcomes Ur    |                   | _               |                      |                                         | 175  |
|    |                                                                                                                                                                                                                                                                                   | 6.3.4 Outcome            | of the            | Voting          | Game                 | '                                       | 175  |
|    | 6.4                                                                                                                                                                                                                                                                               |                          |                   | ler Harm        | onization            | Policy                                  | 176  |
|    |                                                                                                                                                                                                                                                                                   | 6.4.1 Harmonization Po   | olicy             |                 |                      |                                         | 176  |
|    |                                                                                                                                                                                                                                                                                   | 6.4.2 Case I             |                   |                 |                      |                                         | 177  |
|    |                                                                                                                                                                                                                                                                                   | 6.4.3 Case II            |                   |                 |                      |                                         | 179  |
|    | 6.5                                                                                                                                                                                                                                                                               | Conclusions              |                   |                 |                      |                                         | 180  |
| 7. | Sui                                                                                                                                                                                                                                                                               | mmary of Findings        |                   |                 |                      |                                         | 182  |
| Bi | bliog                                                                                                                                                                                                                                                                             | raphy                    |                   |                 |                      |                                         | 185  |