

# Essays in Total Factor Productivity Measurement

DISSERTATION

zur Erlangung des akademischen Grades

Dr. rer. pol.

im Fach Volkswirtschaftslehre

eingereicht an der

Wirtschaftswissenschaftlichen Fakultät

Humboldt-Universität zu Berlin

von

**Herrn Battista Severgnini, M. Sc. Econ.**

geboren am 01.04.1977 in Crema (Italien)

Präsident der Humboldt-Universität zu Berlin:

Prof. Dr. Dr. h.c. Christoph Marksches

Dekan der Wirtschaftswissenschaftlichen Fakultät:

Prof. Oliver Günther, Ph.D.

Gutachter:

1. Prof. Michael C. Burda, Ph.D.

2. Prof. Irwin L. Collier, Ph.D.

**eingereicht am:** 10. November 2009

**Tag der mündlichen Prüfung:** 08. Februar 2010

# Contents

<b>1. TFP Measurements: An Overview</b>	<b>1</b>
1.1. Introduction . . . . .	1
1.2. The Growth Accounting Framework and the Solow Residual . . . . .	3
1.2.1. The Dual Approach . . . . .	4
1.3. The Limits of Growth Accounting . . . . .	5
1.3.1. The Capital Measurement Problem . . . . .	6
1.3.2. Capital Utilization and the Solow Residual . . . . .	8
1.3.3. Spillover Effects and the Solow Residuals . . . . .	9
1.3.4. TFP and non-Cobb-Douglas Production Technologies . . . . .	10
1.3.5. Growth Accounting when Technical Change is Embodied in Capital . . . . .	13
1.4. The Econometrics of Technological Change . . . . .	14
1.4.1. Basic Specifications . . . . .	14
1.4.2. The State-space Approach . . . . .	15
1.4.3. Parametric Methods . . . . .	16
1.4.4. Estimation of the Spillover Effects and Endogeneity Problems . . . . .	17
1.5. Data Envelopment Analysis and the Malmquist Index . . . . .	18
1.5.1. The Malmquist Index . . . . .	19
1.6. Conclusion . . . . .	20
<b>2. Solow Residuals without Capital Stocks (with Michael C. Burda)</b>	<b>23</b>
2.1. Introduction . . . . .	23
2.2. Measurement Error, Depreciation and Capital Utilization . . . . .	24
2.3. Capital Measurement and the Solow Residual: a Quantitative Assessment . . . . .	25
2.3.1. The Stochastic Growth Model as a Laboratory . . . . .	25
2.3.2. Construction of the Data Sets . . . . .	27
2.3.3. Evaluating Measurement Error of the Solow Residual . . . . .	30
2.4. TFP Growth Measurement without Capital Stocks: Two Alternatives . . . . .	32
2.4.1. Direct Substitution (DS) . . . . .	32
2.4.2. Generalized Differences of Deviations from the Steady State (GD) . . . . .	33
2.4.3. The Need for Numerical Evaluation . . . . .	33
2.4.4. Assessing Alternative Measures of TFP Growth: a Horse Race . . . . .	34
2.5. Application: TFP growth in the German federal States . . . . .	37
2.6. Conclusion . . . . .	43
<b>3. State-space Models, Technological Change, and Initial Conditions</b>	<b>45</b>
3.1. Introduction . . . . .	45
3.2. The State-space Representation and TFP Measurement . . . . .	47
3.2.1. Observation Equation and Törnqvist Index . . . . .	48
3.2.2. The Transition Equation . . . . .	50

3.2.3.	The Matrix Representation . . . . .	50
3.2.4.	Computation of the Kalman Filter and Maximum Likelihood Estimation . . . . .	51
3.3.	The Initial Condition Problem . . . . .	52
3.3.1.	The Econometric Approach . . . . .	52
3.3.2.	A Bayesian Procedure: the Gibbs-sampler . . . . .	54
3.3.3.	The Malmquist Index Approach and Growth Accounting . . . . .	55
3.4.	The Stochastic Growth Model . . . . .	56
3.4.1.	Construction of the Data Sets . . . . .	57
3.5.	Horse Race Results . . . . .	59
3.6.	State-space Model with Panel Structure . . . . .	59
3.6.1.	Reverse Engineering . . . . .	60
3.6.2.	Results from Numerical Simulations: A Tour with the Gibbs-sampler . . . . .	61
3.7.	Empirical Application: Danish KLEMS Dataset . . . . .	61
3.7.1.	Test for Unit Root . . . . .	66
3.8.	Conclusion . . . . .	73
<b>4.</b>	<b>Is 'ICT a Jack-in-the-Box? A Counterfactual Approach for Identifying TFP Spillovers.</b>	<b>77</b>
4.1.	Introduction . . . . .	77
4.2.	The Peculiarity of ICT Investments . . . . .	80
4.3.	Counterfactuals and the Malmquist index . . . . .	81
4.4.	The Econometric Specification . . . . .	83
4.4.1.	Identifying the Technological Space . . . . .	84
4.5.	The Need for Quantile Regressions Analysis . . . . .	85
4.5.1.	The Machado and Mata Technique . . . . .	86
4.6.	The Italian Case . . . . .	87
4.6.1.	The <i>Uni Credit Group</i> Dataset . . . . .	87
4.6.2.	Quantile Regression Analysis . . . . .	89
4.7.	Empirical Analysis . . . . .	99
4.7.1.	Counterfactual Analysis . . . . .	100
4.8.	Conclusion . . . . .	101
<b>A.</b>	<b>Appendix to Chapter 2</b>	<b>109</b>
<b>B.</b>	<b>Appendix to Chapter 3</b>	<b>115</b>
<b>C.</b>	<b>Appendix to Chapter 4</b>	<b>121</b>