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博 士 学 位 论 文

利比里亚的能源经济建模:输出需求,替代燃料,可再生能源的估值和能源价格波动

Modeling Liberia's Energy Economy: from the Margin to the Mainstream

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摘要

能源消费对经济增长和发展的重要性要求一个更高的、可持续的能源转型决策来支持。鉴于传统燃料成本和其对能源投资决策的承受力的不确定性，增强环境可持续的新增长路径的必要性和填补利比里亚在相关领域研究的空白，目前的研究将会提供一个解决以上问题的机会。

本论文通过比较四个国家：南非、加纳、尼日利亚和中国，力求达到以下目标：（1）在把就业作为附加变量的情况下，建立利比里亚能源使用和输出的格兰杰因果关系的模型；（2）估计利比里亚的制造技术，以了解和分析这个国家目前的生产方法；（3）分解利比里亚的生产模型，以求出投入产出弹性和估计替代的广度；（4）对可再生能源技术进行估值，以提供利比里亚可再生能源发展的经济学见解；（5）建立石油价格冲击和能源价格波动的频度的模型，并以此为基础来发展有效的能源风险对冲策略。现在已有数个基于最严格的统计和计量的发现。

首先，该研究指出，利比里亚不同于南非，南非的能源消费和经济增长具有双向格兰杰因果关系，因此利比里亚旨在减少二氧化碳排放的能源节约政策可能对经济增长有害。此外，它表明就业的格兰杰效应对经济增长的影响是与周期的长短无关的。此外，蒙特卡洛实验揭示了，因为利比里亚数据的长度问题，渐进的格兰杰因果检验需要改变，这也意味着运用引导技术是更合适的。

其次，本文还表明，资本、劳动力、石油和电力，不仅仅是产出的驱动因素，同样也是替代品。这说明价格导向的政策和资本补贴计划应该一起使用来作为技术导向，这样可以保证清洁能源（例如电力）的成功，因此，在减少温室气体排放的同时，应该确保燃料的充足以维持经济的发展。能源和劳动力、能源和资本之间的替代关系意味着利比里亚的最高限价将导致能源消费的减少、资本的增加，以及劳动密集性加剧。中国目前就是这样的状况。然而，从利比里亚的价格分析看起来，还没有与四大投入要素相关的技术即将出现的证据，这也意味着在劳动

力投入持续超过资本投入的同时，石油将继续在利比里亚的经济中占据能源消费的主导地位。

第三，一个最佳的实物期权方法表明，可再生能源技术对于利比里亚十分具有经济吸引力，尤其是在外部成本内生之后。但是，每年的研究开发资金很低，因此该类资金需要大幅度增加，以保证用最少的支出来获得最大可能的投资积极性。该研究解释了，在可再生能源替代不可再生能源的可能性之下，利比里亚的可再生能源能够潜在地使二氧化碳排放在 2015 年降低大概 13.9%（相对于 2008 年），实物期权分析提供的这个关键见解是，可再生能源技术拥有显而易见的价值。这个价值只有在外部性内生之后才能体现出来，因此我们强调，需要一个碳排放定价政策。

最后，在分析油价波动的短期影响时，油价受到正向冲击会刺激利比里亚的经济。本文认为，当利比里亚的油价上升时，重新配置资源的高成本将从石油密集型到劳动密集型转变。到目前为止，劳动密集型产业在利比里亚 GDP 中所占比例仍超过石油。此外，加纳的天然气市场的大体显示，石油和天然气价格的极不稳定导致了像利比里亚这样的国家能源领域严重的投资不足。通过查阅尼日利亚和加纳的石油出口，利比里亚作为未来潜在的石油出口国极有可能面临更高的波动溢出和期货对冲困难。

基于以上研究结果，本文在第十章提出并讨论了针对利比里亚的相关政策启示。事实上，此博士论文的贡献十分突出。大部分内容已经在《Energy》、《Energy Policy》、《Energy Economics》、《Journal of Cleaner Production》和《Renewable & Sustainable Energy Reviews》等杂志发表。

关键词： 能源经济；燃料替代；可再生能源估价；能源价格波动；利比里亚

Abstract

The importance of energy consumption for growth and development calls for improved decision support for a sustainable energy transition. Given the uncertainty of traditional fuel costs and their bearing on energy investment decision planning as well as the need for new growth pathways that enhance environmental sustainability and the urgency to fill Liberia's devastating research gap, the current study would present opportunities.

This thesis aims at achieving the following while drawing comparisons with other countries like South Africa, Ghana, Nigeria and China: (i) model the direction of Granger causality between energy use and output in Liberia while incorporating employment as additional variable (ii) estimate Liberia's production technology in order to gain insights on and analyze the country's current recipe for production (iii) decompose Liberia's production model in order to extract output elasticities and estimate how various inputs would substitute (iv) value renewable energy technologies to provide insights on the economics of renewable energy expansion in Liberia and (v) model the effects of oil price shocks and the dynamics of energy price volatility as a basis for developing effective hedging strategies against energy risk. Several findings have been documented from applying the most rigorous econometric and statistical techniques.

First, the study points to evidence of distinct bidirectional Granger causality between energy consumption and economic growth in Liberia suggesting that energy conservation policies aimed at reducing carbon dioxide emissions would be harmful to growth. Additionally, it shows that employment Granger causes economic growth irrespective of the short- or long-run formulation. Moreover, Monte Carlo experiment reveals that the asymptotic Granger causality test suffers size distortion problem for

Liberian data, suggesting that use of the bootstrap technique is more appropriate. Similar analysis performed for South Africa shows slightly different results.

Second, the thesis also shows that capital, labor, petroleum and electricity, in addition to being drivers of output, are also substitutes, suggesting that price-based policies coupled with capital subsidy programs can be adopted to redirect technology use towards cleaner energy sources like electricity; hence, retaining the ability to fuel the economy, while also mitigating greenhouse gas emissions. Substitution between energy and labor and energy and capital implies that removal of price ceilings on energy in Liberia would tend to reduce energy use and increase capital and labor intensiveness. Similar results are obtained for China. However, the analysis on Liberia seems to show no evidence of convergence in relative technological progress of the four inputs implying that petroleum will continue to play a dominant role in the energy consumption mix of the Liberian economy while labor investment will continue to outweigh capital inputs.

Third, an optimal real options solution shows that renewable energy technologies are economically attractive for Liberia especially when external costs are internalized. However, annual research & development funding is low and should be raised significantly in order to guarantee the highest possible investment incentive with minimal expenditures. The study demonstrates that with the likelihood of renewable energy to replace nonrenewable energy, renewable power in Liberia can potentially reduce carbon dioxide emissions by approximately 13.9% by 2015 compared with the 2008 levels. The key insight provided by the real options analysis is that renewable energy technologies hold a significant amount of value which can only be detected when externalities are internalized, thus underscoring the need for carbon pricing policies.

Finally, when analyzing short-run impacts of oil price fluctuations, it is the case that positive shocks to oil prices would stimulate the Liberian economy. This thesis argues that when oil price increases in Liberia, the high costs of reallocating resources from oil-intensive sectors lead to labor intensiveness; whose contribution to Liberian GDP by far exceeds that of oil. In addition, the analyses on Ghana and the natural gas market in general have shown that oil and gas prices are highly volatile bringing serious investment disadvantages to a country like Liberia that suffers severe infrastructural gap in the energy sector. Referencing results obtained for the oil-exporting Nigeria and Ghana, Liberia being a future potential oil-exporter is likely to face even higher volatility spillovers and hedging difficulties in the future.

Based on the above findings, the dissertation presents and discusses relevant policy implications for Liberia as profiled in chapter ten. Indeed, the contribution of this work is enormous as most of the contents have been published in journals like 'Energy', 'Energy Policy', 'Energy Economics', 'Journal of Cleaner Production' as well as 'Renewable and Sustainable Energy Reviews'.

Keywords: Energy Economy; Fuel Substitution; Renewable Energy Valuation; Energy Price Volatility; Liberia

Contents

CLAIM OF ORIGINALITY.....	ii
COPYRIGHT.....	iii
ABSTRACT (Chinese version).....	iv
ABSTRACT (English version).....	vi
CONTENTS.....	ix
LIST OF TABLES.....	xvii
LIST OF FIGURES.....	xx
CHAPTER 1	
MOTIVATION AND OBJECTIVE OF THE STUDY.....	1
1.1 Introduction.....	1
1.2 Motivation for the study.....	1
1.2.1 New growth pathways are needed for Liberia.....	1
1.2.2 Clamor for environmental sustainability.....	3
1.2.3 Energy investment decision planning is crucial.....	5
1.2.4 Uncertainty of traditional fuel cost.....	5
1.2.5 Liberia suffers a devastating research gap.....	6
1.3 Research objectives.....	6
1.3.1 Model Granger causality between energy and output.....	6
1.3.2 Estimate Liberia’s production technology.....	6
1.3.3 Estimate substitution elasticities of various inputs.....	7
1.3.4 Value Liberia’s renewable energy technologies.....	7
1.3.5 Model nonrenewable energy price uncertainties.....	7
1.4 Motivation for selected topics.....	7
1.4.1 Chapter 2: Liberia’s conflict and economic performance.....	7
1.4.2 Chapter 3: A review of the relevant literature.....	8

1.4.3	Chapter 6: Energy consumption and economic growth.....	8
1.4.4	Chapter 7: Factor substitution and energy demand.....	9
1.4.5	Chapter 8: Valuing renewable energy technologies.....	9
1.4.6	Chapter 9: Energy price volatility and impacts.....	9
1.5	Author’s published work.....	10
1.6	Organization of the thesis.....	10
CHAPTER 2		
LIBERIA’S CONFLICT AND ECONOMIC PERFORMANCE..		
2.1	Introduction.....	12
2.2	Foundations of the Liberian Conflict.....	12
2.2.1	Political Backdrop to the Conflict.....	13
2.2.2	Economic Backdrop to the Conflict.....	18
2.2.3	Stability Issues in Liberia.....	20
2.3	Decades of Macroeconomic Challenges and Prospects.....	22
2.3.1	Socio-Economic Indicators for Liberia.....	22
2.3.2	Real GDP Performance.....	27
2.3.3	Inflation and Unemployment.....	28
2.3.4	Fiscal and Monetary Developments.....	29
2.4	Real Sector Contribution to Economic Growth.....	32
2.4.1	The Contribution of Agriculture & Fisheries.....	32
2.4.2	The Contribution of Forestry.....	32
2.4.3	The Contribution of Mining & Panning.....	33
2.4.4	The Contribution of Manufacturing.....	34
2.4.5	The Contribution of Services.....	34
2.5	Trade and Infrastructural Developments.....	36
2.5.1	Liberia’s Performance in International Trade.....	36
2.5.2	Road Transport Sector Overview.....	38
2.5.3	Water Sector Overview.....	38
2.5.4	ICT Sector Overview.....	39

2.6 Chapter Summary	39
CHAPTER 3	
A REVIEW OF THE RELEVANT LITERATURE	41
3.1 Introduction	41
3.2 Review of energy consumption and economic growth studies	41
3.2.1 Feedback hypothesis.....	43
3.2.2 Growth hypothesis.....	46
3.2.3 Conservation hypothesis.....	46
3.2.4 Neutrality hypothesis.....	47
3.3 Review of energy substitution and demand studies	47
3.3.1 Transcendental logarithmic costs approach.....	47
3.3.2 Other approaches.....	48
3.3.3 Transcendental logarithmic production approach.....	48
3.4 Review of real options application to the energy sector	48
3.4.1 Power generation.....	50
3.4.2 Policy evaluation.....	51
3.4.3 R&D programs.....	52
3.5 Review of energy price volatility and impacts	52
3.5.1 Oil price shocks.....	52
3.5.2 Natural gas price volatility.....	52
3.6 Main findings from existing studies	52
3.6.1 Findings from energy consumption – growth literature.....	52
3.6.2 Findings from energy substitution – demand literature.....	53
3.6.3 Findings from renewable energy valuation literature.....	54
3.6.4 Findings from energy price volatility literature.....	55
CHAPTER 4	
DATA AND DESCRIPTION	56
4.1 Introduction	56
4.2 Data issues and importance	56
4.3 Labor input	57

4.4 Capital input.....	57
4.5 Technological change.....	58
4.6 Energy prices.....	58
4.6.1 Oil prices.....	58
4.6.2 Natural gas prices.....	61
4.7 Energy consumption.....	61
4.7.1 Total electricity consumption.....	61
4.7.2 Total primary energy consumption.....	62
4.8 GSE/NSE All-Share Index.....	62
4.9 Gross Domestic Product.....	62
CHAPTER 5	
METHODS AND ESTIMATION TECHNIQUES.....	63
5.1 Introduction.....	63
5.2 Unit root testing.....	63
5.2.1 Augmented Dickey–Fuller (ADF) test.....	64
5.2.2 Phillips–Perron (PP) test.....	64
5.2.3 Zivot and Andrew (with one structural break).....	64
5.2.4 Narayan and Popp (with two structural breaks).....	65
5.3 Cointegration testing.....	66
5.3.1 ARDL bounds approach.....	66
5.3.2 Johansen–Juselius.....	67
5.4 Granger causality (VAR model).....	67
5.4.1 Asymptotic test (linear).....	67
5.4.2 Bootstrap test (nonlinear).....	72
5.4.3 Nonparametric test (nonlinear).....	76
5.5 Impulse response function.....	78
5.5.1 Asymptotic approach.....	78
5.5.2 Bootstrap approach.....	78
5.6 Variance decomposition.....	79

5.6.1	Asymptotic approach.....	79
5.6.2	Bootstrap approach.....	79
5.7	Second-order translog production model.....	79
5.7.1	Model specification.....	79
5.7.2	Estimation procedure.....	81
5.8	Inter-fuel substitution and demand estimates.....	83
5.8.1	Estimating output elasticities.....	83
5.8.2	Estimating substitution elasticities.....	84
5.9	Real options valuation.....	86
5.9.1	Model specification.....	89
5.9.2	Estimation procedure.....	93
5.10	Energy price volatility.....	93
5.10.1	VAR – GARCH model specification.....	93
5.10.2	DCC – GARCH model specification.....	96
5.10.3	VAR – AGARCH model specification.....	97
5.10.4	Portfolio management with oil risk.....	98
5.10.5	Markov – Switching volatility specification	99
5.10.6	Estimation procedure.....	102
CHAPTER 6		
ENERGY CONSUMPTION AND ECONOMIC GROWTH.....		105
6.1	Energy consumption and economic growth in Liberia.....	105
6.1.1	Introduction.....	105
6.1.2	Overview of Liberia’s energy sector.....	108
6.1.3	Estimates of energy consumption – economic growth nexus.....	111
6.2	Energy consumption and economic growth in South Africa.....	121
6.2.1	Introduction.....	121
6.2.2	Overview of South African energy sector.....	124
6.2.3	Estimates of energy consumption – economic growth nexus.....	127
6.3	Chapter summary.....	140

6.3.1	Key findings for Liberia.....	140
6.3.2	Key findings for South Africa.....	141
6.3.3	How do results compare?.....	142

CHAPTER 7

FACTOR SUBSTITUTION AND ENERGY DEMAND.....143

7.1 Technical change, inter-factor and inter-fuel substitution in Liberia....143

7.1.1	Introduction.....	143
7.1.2	Output elasticity of alternative inputs.....	147
7.1.3	Substitution elasticity of alternative inputs.....	151
7.1.4	Relative technological progress.....	154

7.2 Estimates of energy substitution in Chinese chemical industry.....155

7.2.1	Introduction.....	155
7.2.2	A synopsis of Chinese chemical industry.....	157
7.2.3	Output elasticity of alternative inputs.....	159
7.2.4	Substitution elasticity of alternative inputs.....	163
7.2.5	Relative technological progress.....	166

7.3 Chapter summary.....167

7.3.1	Key findings for Liberia.....	167
7.3.2	Key findings for China.....	168
7.3.3	How do results compare?.....	169

CHAPTER 8

VALUATION OF RENEWABLE ENERGY TECHNOLOGIES...170

8.1 Renewable energy technologies as beacon of cleaner production in Liberia.....170

8.1.1	Introduction.....	170
8.1.2	Liberia's energy challenges and prospects.....	173
8.1.3	Policy framework for renewable energy development.....	177
8.1.4	Base case scenario for renewable energy valuation.....	178
8.1.5	Renewable energy scenario in which external costs are internalized.....	182

8.1.6	Optimizing the level of renewable energy funding.....	184
8.2	Valuing Chinese feed-in tariffs for solar power generation.....	186
8.2.1	Introduction.....	186
8.2.2	Base case valuation analysis.....	188
8.2.3	Valuation scenario in which external costs are internalized.....	192
8.2.4	Optimizing the rate of feed-in tariffs	195
8.3	Chapter summary.....	197
8.3.1	Key findings for Liberia.....	197
8.3.2	Key findings for China.....	198
8.3.3	How do results compare.....	199
CHAPTER 9		
ENERGY PRICE VOLATILITY AND MACROECONOMIC		
IMPACT.....		
9.1 Oil price shocks and the Liberian economy.....		200
9.1.1	Introduction.....	200
9.1.2	Estimates of how oil shocks impacts the Liberian economy	204
9.1.3	Investigating the asymmetric effects.....	209
9.1.4	Impulse response functions.....	211
9.1.5	Variance decomposition.....	216
9.1.6	Implications of the results for Liberia.....	217
9.2 Oil price volatility and the Ghanaian equity market.....		220
9.2.1	Introduction.....	220
9.2.2	Oil prices and the Ghanaian stock market.....	222
9.2.3	Data and preliminary analysis.....	227
9.2.4	Volatility cross-effects in the oil and stock markets.....	230
9.2.5	Performance measure.....	236
9.2.6	Portfolio management with oil-risks hedging strategies.....	237
9.3 Price volatility and regime shifts in the natural gas market.....		239
9.3.1	Introduction.....	239

9.3.2	Reasons for price volatility in the natural gas market.....	244
9.3.3	Forecasting natural gas volatility.....	255
9.3.4	Forecasts performance of competing models.....	257
9.4	Chapter summary.....	258
9.4.1	Key findings for Liberia.....	258
9.4.2	Key findings for Ghana and Nigeria.....	259
9.4.3	Key findings on natural gas volatility.....	260
9.4.4	What do the results mean for Liberia?.....	260
CHAPTER 10		
CONCLUSIONS AND POLICY IMPLICATIONS.....		262
10.1	Energy consumption and economic growth in Liberia.....	262
10.1.1	Conclusions.....	262
10.1.2	Policy implications.....	263
10.2	Technical change, inter-factor and inter-fuel substitution in Liberia....	263
10.2.1	Conclusions.....	263
10.2.2	Policy implications.....	265
10.3	Renewable energy as beacon of cleaner production in Liberia.....	267
10.3.1	Conclusions.....	267
10.3.2	Policy implications.....	269
10.4	Oil price shocks and the Liberian economy.....	270
10.4.1	Conclusions.....	270
10.4.2	Policy implications.....	271
ACKNOWLEDGMENTS.....		272
REFERENCE.....		273

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