Mohamed Sami Ben Ali
Ewa Lechman *Editors*

Sustainable Economic Development

Fostering the United Nations Goals

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Contents

Chapter 1
Institutional Quality, ICT Infrastructure, Transportation, and Sustainable Development: The Case of Lower Income Countries

Rudra P. Pradhan, Mahendhiran S. Nair, John H. Hall, Sara E. Bennett, and Sahar Bahmani

Abstract Transportation is critical for the sustainable development of countries across the globe. A sound transportation system is important for the movement of goods, services, and people worldwide. In many developed economies, significant investments are channelled to develop efficient transportation systems. Intensifying investments in ICT and institutions of governance are critical to ensure that the transportation system deepens its impact on economic growth. Key challenges faced by many lower income countries (LICs) are lack of resources to increase investments in advanced transportation infrastructure and improving governance of the transportation system. This dampens economic growth in LICs. The present study examines the relationship between ICT infrastructure, transportation system, institutional governance, and economic growth in LICs using the panel VAR model from 2005 to 2022. The empirical analysis shows strong short-run and long-run dynamics between the

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variables; hence, careful curation of co-development policies is needed to enable LICs to transition onto a path of sustained economic growth.

Keywords Institutional quality · Transportation · ICT infrastructure · Economic growth · SDGs · Low-income countries

1.1 Introduction

This study examines the intricate relationship between institutional quality, ICT infrastructure, transportation, and sustainable economic growth in lower income countries (LICs), especially small island and landlocked countries. Over the last decade, the importance of well-developed transportation networks has been underscored through the lens of the UN's Sustainable Development Goals (SDGs), with specific relevance to SDG-8 (*decent work and economic growth*), SDG-9 (*industry, innovation, and economic growth*), and SDG-11 (*sustainable cities and communities*). The UN-SDGs emphasizes the importance of good and affordable transportation systems to make cities and human settlements inclusive, safe, and accessible to all segments of the population. Good transportation systems are important for creating vibrant economic development and access to vital public services (Sadiq et al., 2023; and Taghvaee et al., 2023).

There is consensus among policymakers and economists that there are strong interrelationships between transportation and economic growth. However, the direction of causality between these variables is rather unclear in the literature. There are studies that argue that good quality institutions and the adoption of information and communication technologies (ICT) help countries to get better return on value (ROV) from their infrastructure investments. The studies show that investments in improving institutional governance and critical infrastructure (such as the transportation network) are important drivers for creating vibrant economic ecosystems and improving the quality of life of people (Owen, 1959; Rodrik et al., 2004; Ben Ali & Sassi, 2016; Zayati & Ben Ali, 2023, Zayati & Ben Ali, 2023; Ben Ali, 2023, Ben Ali, 2023; Pradhan et al., 2023a and 2023b).

The linkages between institutional quality investments in transportation infrastructure, ICT, and economic growth are rather complex. Unpacking this complexity will provide valuable insights into the types of co-development policies for ensuring LICs are able to get better ROV from these investments. To unravel the complex relationships between transportation, economic growth, institutional quality, and ICT, the study employs the panel VAR data modelling method on a sample of 79 lower income countries (LICs). The short-run and long-run dynamics derived from the empirical analysis will provide valuable insights on co-development policies pertaining to institutional governance, ICT infrastructure development, and transportation system to enable LICs to transition towards a more sustainable economic growth trajectory. The paper is organized into four remaining sections: literature and the development of hypotheses, empirical approach, results, and policy implications.

1.2 Relative Literature and Hypothesis Development

This section examines the pair-wise causal relationship between institutional quality, ICT, transportation, and economic growth. The pairwise comparison examines the existence of Granger-Causal (GC) relationships between these co-variates. In this context, we examine four major hypotheses, and they are supply-leading, demand-following, feedback, and the neutrality hypothesis.

First, we examine the link between transportation and economic growth, particularly in terms of these four hypotheses—(1) *supply-leading hypothesis* (H_{1A}), where transportation Granger-Cause (GC) economic growth (Alam et al., 2021; Zhang & Cheng, 2023; Zhu et al., 2022); (2) *demand-following hypothesis* (H_{1B}), where economic growth GC transportation (Arvin et al., 2015; Nguyen, 2023; Pradhan et al., 2021a); (3) the *feedback hypothesis* ($H_{1A,B}$), where transportation and economic growth GC one another (Pradhan, 2019; Pradhan et al., 2023b; Zhu et al., 2022); and (4) the *neutrality hypothesis*, where transportation and economic growth do not GC one another (Mohmand et al., 2021; Pradhan & Bagchi, 2013).

Second, the GC link between ICT infrastructure and economic growth, particularly in terms of these four hypotheses—(1) *supply-leading hypothesis* (H_{2A}), where ICT infrastructure GC economic growth (Pradhan et al., 2023b and 2020a); (2) *demand-following hypothesis* (H_{2B}), where economic growth GC ICT (Pradhan et al., 2021a; Nair et al., 2020; and Pradhan et al., 2022a); (3) the *feedback hypothesis* ($H_{2A,B}$), where ICT and economic growth GC one another (Pradhan et al., 2021b; and Pradhan et al., 2018); and (4) the *neutrality hypothesis*, where ICT and economic growth do not GC one another (Pradhan et al., 2023b and 2020b).

Third, the GC link between institutional quality and economic growth, particularly in terms of these four hypotheses—(1) *supply-leading hypothesis* (H_{3A}), where institutional quality GC economic growth (Pradhan et al., 2023c; Ben Ali, 2023; Ben Ali, 2023; Gurus and; Ben Ali, 2023; Ben Ali, 2023; Zayati & Ben Ali, 2023; Zayati & Ben Ali, 2023; Ben Ali et al., 2020; Ben Ali & Sorin, 2016); (2) *demand-following hypothesis* (H_{3B}), where economic growth GC institutional quality (Pradhan et al., 2022a; Nair et al., 2021; Ben Ali & Acikgoz, 2019; Swaleheen et al., 2019; Saha & Ben Ali, 2017; Ben Ali & Sassi, 2016; Ben Ali & Mdhillat, 2015); (3) the *feedback hypothesis* ($H_{3A,B}$), where institutional quality and economic growth GC one another (Pradhan et al., 2023a); and (4) the *neutrality hypothesis*, where institutional quality and economic growth do not GC one another (Pradhan et al., 2023c).

Fourth, the link between transportation GC ICT, particularly in terms of these four hypotheses—(1) *supply-leading hypothesis* (H_{4A}), where transportation GC ICT (Pradhan et al., 2023a and Adedoyin et al., 2020); (2) *demand-following hypothesis* (H_{4B}), where ICT GC transportation (Sun et al., 2022; Park et al., 2019); (3) the *feedback hypothesis* ($H_{4A,B}$), where ICT and transportation GC one another (Pradhan et al., 2023a); and (4) the *neutrality hypothesis*, where transportation and ICT do not GC one another (Pradhan et al., 2023a).

Fifth, the link between transportation and institutional quality, particularly in terms of these four hypotheses—(1) *supply-leading hypothesis (*H_{5A}), where transportation

GC institutional quality (Soh et al., 2021); (2) *demand-following hypothesis* (H_{5B}), where institutional quality GC transportation (Docherty et al., 2018); (3) the *feedback hypothesis* ($H_{5A,B}$), where institutional quality and transportation GC one another (Pradhan et al., 2023a); and (4) the *neutrality hypothesis*, where transportation and institutional quality do not GC one another (Pradhan et al., 2023a).

Sixth, the link between ICT and institutional quality, particularly in terms of these four hypotheses—(1) *supply-leading hypothesis* (H_{6A}), where ICT GC institutional quality (Pradhan et al., 2023b); (2) *demand-following hypothesis* (H_{6B}), where institutional quality GC ICT (Pradhan et al., 2023b); (3) the *feedback hypothesis* ($H_{6A,B}$), where institutional quality and ICT GC one another (Pradhan et al., 2023b); and (4) the *neutrality hypothesis*, where ICT and institutional quality do not GC one another (Pradhan et al., 2023b).

The details of these hypotheses are not highlighted here due to space restrictions. However, a summary of the literature review for these sets is presented in Table 1.1.

There has been earlier research on the foundations of these four co-variates. However, only a restricted number of studies investigate the interactions between these co-variates deploying advanced panel data techniques. In this study, we examine the short- and long-run relationship between the variables using the panel VAR model. The hypotheses tested are as follows[1]:

$H_{1A,B}$: *Transportation* ***GC*** *sustainable economic growth, and* vice versa.
$H_{2A,B}$: *ICT infrastructure* ***GC*** *sustainable economic growth, and* vice versa.
$H_{3A,B}$: *Institutional quality* ***GC*** *sustainable economic growth, and* vice versa.
$H_{4A,B}$: *Transportation* ***GC*** *ICT infrastructure, and* vice versa.
$H_{5A,B}$: *Transportation* ***GC*** *institutional quality, and* vice versa.
$H_{6A,B}$: *Institutional quality* ***GC*** *ICT infrastructure, and* vice versa.

1.3 Data, Variables, and Estimation Approach

In this study, we unpack the complex relationships between economic growth, institutional quality, ICT, and transportation infrastructure using a panel VAR model and the Granger causality (GC) technique to explore the dynamics between these four variables *simultaneously*. The hypotheses were tested for 79 LICs during the period 2005–2022. While many of these countries have lower income levels, they are rich in natural resources.[2] Additionally, several of these countries are either small islands or landlocked countries that experience unique challenges with respect to providing good transportation systems.

The data was obtained from WDI and the CPIA databases, both published by the World Bank. The variables used in the study are real per capita economic growth

[1] Detailed literature review that led to the formulation of the hypothesis can be obtained from the authors. It was not included due to space constraints.

[2] The categorization of the countries is followed on the World Bank's classification. They are not highlighted here due to space restrictions.

Table 1.1 Selected studies on the possible nexus between institutional quality, transportation, ICT infrastructure, and sustainable economic growth

Authors	Study area	Time frame	Major findings
Part A: Studies focusing on Links between Transportation and sustainable development			
Zhu et al. (2022)	China	1980–2015	F^1
Pradhan and Bagchi (2013)	India	1970–2010	F^1
Yetkiner and Beyzatlar (2020)	18 countries	1970–2017	F^1
Meersman and Nazemzadeh (2017)	Belgium	1979–2012	D^1
Mohmand et al. (2021)	Pakistan	1971–2017	F^1
Part B: Studies focusing on Links between ICT infrastructure and sustainable development			
Nair et al. (2021)	Developing countries	2005–2018	D^2, S^2, F^2
Arvin et al. (2021b)	Middle-income countries	2005–2019	F^2
Part C: Studies focusing on Links between institutional quality and sustainable development			
Nair et al. (2021)	Developing countries	2005–2018	D^3, S^3, F^3
Saidi and Mbarek (2017)	Developed countries	1990–2013	D^3
Part D: Studies focusing on Links between Transportation and ICT infrastructure			
Zergawu et al. (2020)	99 countries	1980–2015	D^4
Part E: Studies on the Link between ICT infrastructure and Institutional Quality			
Nair et al. (2021)	Developing countries	2005–2018	D^5, S^5, F^5
Karim et al. (2022)	SSA countries	2000–2021	S^5

Note 1: D stands for demand-following hypothesis; S stands for supply-leading hypothesis; F stands for feedback hypothesis; N stands for neutrality hypothesis
Note 2: D^1: Granger causality from transportation infrastructure to sustainable development only; S^1: Causality from sustainable development to transportation infrastructure only; F^1: Bidirectional Granger causality between transportation infrastructure and sustainable development; and N^1: No causality between transportation infrastructure and sustainable development
Note 3: D^2: Granger causality from institutional quality to sustainable development; S^2: Granger causality from sustainable development to institutional quality only; F^2: Bidirectional Granger causality between sustainable development and institutional quality; and N^2: No causality between institutional quality and sustainable development
Note 4: D^3: Granger causality from ICT infrastructure to sustainable development only; S^3: Granger causality from sustainable development to ICT infrastructure only; F^3: Bidirectional Granger causality between ICT infrastructure and sustainable development; and N^3: No causality between ICT infrastructure and sustainable development
Note 5: D^4: Granger causality from institutional quality to transportation infrastructure only; S^4: Granger causality from transportation infrastructure to institutional quality only; F^4: Bidirectional Granger causality between transportation infrastructure and institutional quality; and N^4: No causality between transportation infrastructure and institutional quality
Note 7: D^5: Granger causality from institutional quality to ICT infrastructure only; S^5: Granger causality from ICT infrastructure to institutional quality only; F^5: Bidirectional Granger causality between ICT infrastructure and institutional quality; and N^5: No causality between ICT infrastructure and institutional quality
Note 8: The more detailed literature relating to the linkage between institutional quality and economic growth can be explored in Pradhan et al. (2023a, b, c)

(PEG), six indicators for transportation (TRA), a composite index for institutional quality (CIQ), and a compound index for ICT (ICI). The transportation indicators are goods transported in railways (TR1), passengers carried in railways (TR2), rail lines (TR3), freight in air transport (TR4), passengers carried in air transport (TR5), and registered carrier departures worldwide in air transport (TR6).

The institutional quality (CIQ) is a composite index of 10 CPIA institutional indicators. The index was developed using PCA—principal component analysis.[3] The ICT composite index consists of six indicators.[4] The details of these indices' formulation (for both institutional quality and ICT) are not given here, but may be requested from the authors.[5] Additionally, we use CPIA indicators to arrive at the CIQ index. These include business regulatory environment rating (CBE), building human resources rating (CBH), debt policy rating (CDP), financial sector rating (CFS), economic management cluster average rating (CEM), efficiency of revenue mobilization rating (CER), macroeconomic management rating (CMM), quality of budgetary and financial management rating (CQF), quality of public administration rating (CQP), accountability, transparency, and corruption in the public sector rating (CTP).

We consider six cases based on the use of six transportation indicators (TR1–TR6). For each case, we consider 11 specifications that were based on the 11 institutional quality indicators (the 10 individual indicators and the composite index). We present a set of 6 × 11 relationships to capture the dynamics between the variables. We examine a set of panel regressions to capture the dynamics of the variables as shown below

$$\begin{gathered}\Delta\text{Sustainable economic growth}_{it} = \Omega_{1j} + \\ \sum_{k=1}^{q}\beta_{1ik}\Delta\text{Sustainable economic growth}_{it-k} + \sum_{k=1}^{q}\delta_{1ik}\Delta\text{Transportation}_{it-k} + \\ \sum_{k=1}^{r}\lambda_{1ik}\Delta\text{ICT Infratsructure}_{it-k} + \sum_{k=1}^{s}\mu_{1ik}\Delta\text{Institutional quality}_{it-k} + \\ \rho_{1i}\text{ECT}_{it-1} + \xi_{1it}\end{gathered} \tag{1.1}$$

$$\begin{gathered}\Delta\text{Transportation}_{it} = \Omega_{1j} + \\ \sum_{k=1}^{q}\beta_{1ik}\Delta\text{Transportation}_{it-k} + \sum_{k=1}^{q}\delta_{1ik}\Delta\text{Sustainable economic growt}h_{it-k} + \\ \sum_{k=1}^{r}\lambda_{1ik}\Delta\text{ICT Infratsructure}_{it-k} + \sum_{k=1}^{s}\mu_{1ik}\Delta\text{Institutional quality}_{it-k} + \\ \rho_{1i}\text{ECT}_{it-1} + \xi_{1it}\end{gathered} \tag{1.2}$$

[3] The variables used to construct the CIQ are listed in the CPIA database.

[4] These include telephone landlines, mobile phones, Internet servers, Internet users, and fixed broadband automatic teller machine. The data are obtained from the WDI database.

[5] For details of this procedure, refer to Nair et al. (2021) and Pradhan et al. (2023a).

$$\Delta\text{ICT Infratsructure}_{it} = \Omega_{1j} + \sum_{k=1}^{q} \beta_{1ik}\Delta\text{ICT Infratsructure}_{it-k} + \sum_{k=1}^{q} \delta_{1ik}\Delta\text{Transportation}_{it-k} + \sum_{k=1}^{r} \lambda_{1ik}\Delta\text{Sustainable economic growth}_{it-k} + \sum_{k=1}^{s} \mu_{1ik}\Delta\text{Institutional quality}_{it-k} + \rho_{1i}\text{ECT}_{it-1} + \xi_{1it} \tag{1.3}$$

$$\Delta\Delta\text{Institutional quality}_{it} = \Omega_{1j} + \sum_{k=1}^{q} \beta_{1ik}\Delta\text{Institutional quality}_{it-k} + \sum_{k=1}^{q} \delta_{1ik}\Delta\text{Transportation}_{it-k} + \sum_{k=1}^{r} \lambda_{1ik}\Delta\text{ICT Infratsructure}_{it-k} + \sum_{k=1}^{s} \mu_{1ik}\Delta\text{Sustainable economic growth}_{it-k} + \rho_{1i}\text{ECT}_{it-1} + \xi_{1it} \tag{1.4}$$

where ECT_{-1} represents the error-correction term, indicating the long-run dynamics inherent in the set of equations, signified by 1–4. The coefficient of the first-difference variables illustrates the short-run dynamics.

1.4 Empirical Results

1.4.1 Unit Root and Cointegration Tests

The panel unit root test is first used to detect the order of integration of the data series. The test confirms that the variables are integrated into order one. Then, the panel cointegration test was undertaken, and it showed that there exists cointegration relationships between the variables. That is, there exist long-run relationships between transportation, institutional quality, ICT, and economic growth.

1.4.2 Long- and Short-Run Granger Causality Results

Using the panel vector error-correction model, we determine the possible GC relationships among transportation, ICT, institutional quality, and economic growth. Our estimation results for the six cases and 11 specifications under each case are offered in Table 3.

First, we examine the long-run GC relationship by examining the ECT_{-1} coefficients. A steady model has ECT_{-1} with negative signs, with an interval from -1 to 0. From our estimated results, we found that with Δ sustainable economic growth, the lagged ECTs were negative and significant, with a p-value of $p \leq 0.01$.

This suggests that economic growth converges to its long-run path in response to fluctuations in transportation, ICT, and institutional quality. The deviation from the long-run equilibrium between these variables is about 51% to 81% (see Table 1.1). This causal flow was found to be true for *all* 66 scenarios (i.e., six cases and 11 specifications under every case) that we examined. Consequently, we conclude that sustainable economic growth in LICs is significantly affected by transportation, ICT infrastructure, and institutional quality in the period under review. This suggests that long-run economic growth in LICs is dependent on the transportation system, ICT infrastructure, and institutional quality.

Next, we examine short-run causality results, which are obtained by examining the significance of the regressors of the first-difference variables. From the estimated results, we observe that the short-run inferences are non-uniform (see Table 1.2). This exhibits that the short-run dynamics vary across the six cases and eleven specifications.

Based on Table 1.2, the results regarding the various hypotheses can be discussed.

Hypothesis 1 relates to the *GC between transportation and sustainable economic growth*. For this link, 22 out of 66 specifications support the supply-leading hypothesis, indicating that sustainable economic growth drives transportation infrastructure development. This supports H_{1B} across all institutional quality indicators. The result is the same as one in the study by Kaya and Aydin (2024) for European countries using panel data during 2002–2021, Nenavath (2023) for India during 1990–2020, and Pradhan (2019) for the G-20 countries during 1961–2016. We also find that 44 out of 66 specifications support the feedback hypothesis, indicating that sustainable economic growth and transportation drive each other. This supports $H_{1A,B}$ across all institutional quality indicators. These bidirectional findings are generally consistent with the study by Nguyen (2023) for Asia using panel data during 1975–2019, Zhu et al. (2022) for China by deploying province-level panel data during 1980–2015, Mohmand et al. (2021) for Pakistan during 1971–2017, and Pradhan and Bagchi (2013) for India during 1970–2010.

For Hypothesis 2, which relates the nexus between ICT and sustainable economic growth, 22 out of 66 specifications support the demand-following hypothesis, specifying that ICT drives sustainable economic growth. This supports H_{2A} across all institutional quality indicators. The result is the same as one in the study by Pradhan et al. (2021a) for the G-20 countries during 1961–2016 and Pradhan et al. (2021b) for India using provincial data during 1991–2018. We also find that 33 out of 66 instances support the feedback hypothesis, designating that ICT and sustainable development drive each other. This supports $H_{2A,B}$ across all institutional quality indicators. These bidirectional findings are generally consistent with the study by Pradhan et al. (2022) for middle-income countries using panel data during 2005–2019, Pradhan et al. (2021b) for India using provincial data during 1991–2018, and David (2019) for Africa during 2000–2015. We also find support for the neutrality hypothesis in 11 instances, indicating that sustainable development and ICT infrastructure do not cause each other. This is the case when transportation indicators are used for rail lines only. This finding is congruent with the study by Saba et al. (2023a) for developing countries during 2000–2018, Kurniawati (2022) for Asian

Table 1.2 Results of the panel Granger causality test

Case 1: SEG, ICI, GTR, INQ

	Specification 1 (CBE)						Specification 2 (CBH)				
	ΔSEG	ΔICI	ΔGTR	ΔCBE	ECT_{-1}		ΔSEG	ΔICI	ΔGTR	ΔCBH	ECT–1
ΔSEG	–	2.62	4.67**	1.86	–0.57*	ΔSEG	–	2.56	4.69**	1.80	–0.57*
ΔICI	15.1*	–	43.1*	1.39	–0.32	ΔICI	15.2*	–	43.0*	1.41	–0.34
ΔGTR	6.14*	6.07*	–	5.05**	–0.45	ΔGTR	6.48*	6.04*	–	4.70**	–0.44
ΔCBE	7.23*	10.5*	0.40	–	–0.36	ΔCBH	6.16*	9.55*	0.51	–	–0.41
	Specification 3 (CDP)						Specification 4 (CFS)				
	ΔSEG	ΔICI	ΔGTR	ΔCDP	ECT–1		ΔSEG	ΔICI	ΔGTR	ΔCFS	ECT–1
ΔSEG	–	2.69	4.70**	1.02	–0.56*	ΔSEG	–	2.77	4.86**	2.56	–0.56*
ΔICI	14.6*	–	42.9*	1.21	–0.29	ΔICI	14.9*	–	43.5*	1.43	–0.30
ΔGTR	6.55*	–	6.23*	5.65**	–0.45	ΔGTR	6.66*	7.15*	–	8.68*	–0.46
ΔCDP	6.95*	9.40*	0.33	–	–0.70	ΔCES	10.8*	10.7*	1.38	–	–0.49
	Specification 5 (CEM)						Specification 6 (CER)				
	ΔSEG	ΔICI	ΔGTR	ΔCEM	ECT–1		ΔSEG	ΔICI	ΔGTR	ΔCER	ECT–1
ΔSEG	–	2.53	4.73**	1.15	–0.57*	ΔSEG	–	2.55	4.55**	1.14	–0.57*
ΔICI	15.0*	–	43.5*	1.39	–0.31	ΔICI	15.1*	–	43.9*	1.99	–0.31
ΔGTR	6.52*	6.14*	–	5.15**	–0.44	ΔGTR	6.37*	6.09*	–	4 94**	–0.44
ΔCEM	6.76*	11.3*	0.51	–	–0.49	ΔCER	6.06*	8.91*	0.46	–	–0.40
	Specification 7 (CMM)						Specification 8 (CQF)				
	ΔSEG	ΔICI	ΔGTR	ΔCMM	ECT–1		ΔSEG	ΔICI	ΔGTR	ΔCQF	ECT–1
ΔSEG	–	2.43	4.76**	1.16	–0.57*	ΔSEG	–	2.51	4.48**	1.08	–0.57*
ΔICI	15.2*	–	44.0*	1.68	–0.31	ΔICI	15.4*	–	43.3*	0.90	–0.33

(continued)

Table 1.2 (continued)

Case 1: SEG, ICI, GTR, INQ											
ΔGTR	6.51*	5.99*	–	4.69**	–0.44	ΔGTR	6.26*	6.17*	–	5.86*	–0.42
ΔCMM	6.61*	12.6*	1.41	–	–0.37	ΔCQF	8.37*	11.5*	0.75	–	–0.38
	Specification 9 (CQP)						Specification 10 (CTP)				
	ΔSEG	ΔICI	ΔGTR	ΔCQP	ECT–1		ΔSEG	ΔICI	ΔGTR	ΔCTP	ECT–1
ΔSEG	–	2.58	4.47**	1.42	–0.57*	ΔSEG	–	2.65	4.73**	2.36	–0.58*
ΔICI	15.4*	–	43.8*	1.09	–0.33	ΔICI	1.44*	–	42.6*	1.59	–0.30
ΔGTR	6.30*	5.91*	–	4.71**	–0.44	ΔGTR	6.36*	6.65*	–	4.95**	–0.43
ΔCQP	7.13*	11.3*	1.05	–	–0.30	ΔCTP	9.70*	13.9*	0.77	–	–0.29
	Specification 11 (CIQ)										
	ΔSEG	ΔICI	ΔGTR	ΔCIQ	ECT–1						
ΔSEG	–	2.55	4.64**	1.30	–0.57*						
ΔICI	15.1*	–	43.4*	1.31	–0.32						
ΔREC	6.43*	6.11*	–	4.82**	–0.45						
ΔCIQ	7.05*	9.79*	0.88	–	–1.03						
Case 2: SEG, ICI, PCR, INQ											
	Specification 1 (CBE)						Specification 2 (CBH)				
	ΔSEG	ΔICI	ΔPCR	ΔCBE	ECT_{-1}		ΔSEG	ΔICI	ΔPCR	ΔCBH	ECT–1
ΔSEG	–	2.41	11.0*	2.30	–0.59*	ΔSEG	–	2.07	10.8*	2.32	–0.59*
ΔICI	5.15**	–	23.4*	4.51**	–0.05	ΔICI	5.40**	–	23.5*	5.26**	–0.06
ΔPCR	0.77	1.03	–	1.89	–0.10	ΔPCR	0.63	0.89	–	1.87	–0.14
ΔCBE	6.63*	11.7*	6.41*	–	–0.11	ΔCBH	4.92**	10.0*	5.34*	–	–0.09
	Specification 3 (CDP)						Specification 4 (CFS)				

(continued)

Table 1.2 (continued)

Case 2: SEG, ICI, PCR, INQ

	ΔSEG	ΔICI	ΔPCR	ΔCDP	ECT_1		ΔSEG	ΔICI	ΔPCR	ΔCFS	ECT_1
ΔSEG	–	1.99	10.1*	1.15	−0.58*	ΔSEG	–	1.92	10.6*	3.06	−0.58*
ΔICI	5.92**	–	23.7*	5.37**	−0.04	ΔICI	5.27**	–	23.9*	5.91**	−0.05
ΔPCR	0.43*	0.87	–	2.03	−0.20	ΔPCR	0.73	1.07	–	1.64	−0.13
ΔCDP	5.28*	10.4*	7.29	–	−0.41	ΔCES	7.72*	11.3*	6.42*	–	−0.04
	Specification 5 (CEM)						Specification 6 (CER)				
	ΔSEG	ΔICI	ΔPCR	ΔCEM	ECT_1		ΔSEG	ΔICI	ΔPCR	ΔCER	ECT_1
ΔSEG	–	2.10	10.5*	1.47	−0.58*	ΔSEG	–	2.17	10.9*	1.94	−0.59*
ΔICI	5.10**	–	23.9*	5.32**	−0.05	ΔICI	5.15**	–	24.4*	6.13*	−0.05
ΔPCR	0.47	0.92	–	1.77	−0.18	ΔPCR	0.58	0.95	–	1 64	−0.15
ΔCEM	5.15*	11.8*	6.41*	–	−0.22	ΔCER	4.98**	9.86*	7.17*	–	−0.04
	Specification 7 (CMM)						Specification 8 (CQF)				
	ΔSEG	ΔICI	ΔPCR	ΔCMM	ECT_1		ΔSEG	ΔICI	ΔPCR	ΔCQF	ECT_1
ΔSEG	–	2.16	10.8*	1.64	−0.58*	ΔSEG	–	2.22	10.9*	1.73	−0.59*
ΔICI	5.21**	–	24.5*	5.76**	−0.05	ΔICI	5.44*	–	23.5*	4.68**	−0.06
ΔPCR	0.50	0.95	–	1.42	−0.17	ΔPCR	0.72	0.99	–	1.15	−0.12
ΔCMM	5.53*	12.8*	7.42*	–	−0.14	ΔCQF	6.03*	11.6*	6.00*	–	−0.05
	Specification 9 (CQP)						Specification 10 (CTP)				
	ΔSEG	ΔICI	ΔPCR	ΔCQP	ECT_1		ΔSEG	ΔICI	ΔPCR	ΔCTP	ECT_1
ΔSEG	–	2.31	11.1*	2.21	−0.59*	ΔSEG	–	2.31	11.1*	2.58	−0.59*
ΔICI	5.36**	–	23.5*	4.69**	−0.05	ΔICI	5.12**	–	23.4*	7.70*	−0.04
ΔPCR	0.68	0.96	–	1.23	−0.12	ΔPCR	0.78	1.05*	–	2.29	−0.09

(continued)

Table 1.2 (continued)

Case 2: SEG, ICI, PCR, INQ											
ΔCQP	4.88**	11.6*	5.00**	–	–0.03	ΔCTP	8.11*	14.1*	5.41**	–	–0.06
	Specification 11 (CIQ)										
	ΔSEG	ΔICI	ΔPCR	ΔCIQ	ECT–1						
ΔSEG	–	2.07	10.8*	1.87	–0.59*						
ΔICI	5.46**	–	2.41*	5.89*	–0.05						
ΔPCR	0.57	0.94*	–	1.25	–0.15						
ΔCIQ	5.24*	10.5*	6.72*	–	–0.29						
Case 3: SEG, ICI, RAL, INQ											
	Specification 1 (CBE)						Specification 2 (CBH)				
	ΔSEG	ΔICI	ΔRAL	ΔCBE	ECT_{-1}		ΔSEG	ΔICI	ΔRAL	ΔCBH	ECT–1
ΔSEG	–	0.98	4.90**	1.34	–0.54*	ΔSEG	–	0.977	4.36**	1.22	–0.55*
ΔICI	0.46	–	1.25*	9.79*	–0.64	ΔICI	0.38	–	12.5*	6.21*	–0.63
ΔRAL	6.97*	6.25*	–	2.67	–0.27	ΔRAL	6.99*	6.39*	–	2.68	–0.27
ΔCBE	1.77	2.19	13.7*	–	–0.27	ΔCBH	3.08	1.70	12.8*	–	–0.49
	Specification 3 (CDP)						Specification 4 (CFS)				
	ΔSEG	ΔICI	ΔRAL	ΔCDP	ECT–1		ΔSEG	ΔICI	ΔRAL	ΔCFS	ECT–1
ΔSEG	–	1.07	4.84**	0.74	–0.52*	ΔSEG	–	1.26	4.75**	1.57	–0.51*
ΔICI	0.489	–	11.6*	4.70**	–0.79	ΔICI	0.61	–	12.4*	8.51*	–0.96
ΔRAL	6.14*	6.27*	–	3.05	–0.24	ΔRAL	4.92*	5.78*	–	2.31	–0.20
ΔCDP	6.19*	3.53	11.9*	–	–0.84	ΔCES	4.16**	4.22**	11.1*	–	–0.69
	Specification 5 (CEM)						Specification 6 (CER)				
	ΔSEG	ΔICI	ΔRAL	ΔCEM	ECT–1		ΔSEG	ΔICI	ΔRAL	ΔCER	ECT–1

(continued)

Table 1.2 (continued)

Case 3: SEG, ICI, RAL, INQ											
ΔSEG	–	0.99	4.34**	0.39	–0.53*	ΔSEG	–	0.94	5.17**	1.02	–0.54*
ΔICI	0.53	–	12.1*	6.16*	–0.83	ΔICI	0.40	–	12.7*	11.2*	–0.63
ΔRAL	6.43*	6.28*	–	3.13	–0.25	ΔRAL	6.69*	6.13*	–	2 37	–0.26
ΔCEM	4.43**	2.91	12.1*	–	–0.69	ΔCER	1.92	1.40	13.2*	–	–0.32
	Specification 7 (CMM)						Specification 8 (CQF)				
	ΔSEG	ΔICI	ΔRAL	ΔCMM	ECT_1		ΔSEG	ΔICI	ΔRAL	ΔCQF	ECT_1
ΔSEG	–	0.93	4.37**	0.63	–0.54*	ΔSEG	–	1.01	4.96**	0.67	–0.54*
ΔICI	0.44	–	12.1*	7.62*	–0.72	ΔICI	0.52	–	12.0*	5.93**	–0.76
ΔRAL	6.86	6.21*	–	3.01	–0.27	ΔRAL	6.72*	6.51*	–	2.98	–0.26
ΔCMM	2.64	2.76	11.9*	–	–0.55	ΔCQF	4.95**	1.90	13.2*	–	–0.56
	Specification 9 (CQP)						Specification 10 (CTP)				
	ΔSEG	ΔICI	ΔRAL	ΔCQP	ECT_1		ΔSEG	ΔICI	ΔRAL	ΔCTP	ECT_1
ΔSEG	–	1.08	4.68**	0.76	–0.54*	ΔSEG	–	1.09	4.66**	1.74	–0.54*
ΔICI	0.47	–	12.1*	6.67*	–0.71	ΔICI	0.30	–	12.5*	6.30*	–0.51
ΔRAL	6.92*	6.64*	–	2.45	–0.27	ΔRAL	7.42*	6.69*	–	2.67	–0.28
ΔCQP	4.51**	2.92	13.1*	–	–0.44	ΔCTP	2.62	4.64**	11.9*	–	–0.26
	Specification 11 (CIQ)										
	ΔSEG	ΔICI	ΔRAL	ΔCIQ	ECT_1						
ΔSEG	–	1.01	5.14**	0.81	–0.54*						
ΔICI	0.45	–	12.0*	6.40*	–0.75						
ΔRAL	6.57*	6.28*	–	2.74	–0.26						
ΔCIQ	5.23**	2.22	12.4*	–	–0.15						

(continued)