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ICT AND CAUSALITY IN THE NEW ZEALAND ECONOMY

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ABSTRACT

The focus of the paper is on examining the long-run and potentially *causal relationship* between ICT and economic performance, in part to test the endogenous technology growth model. The paper provides a detail description of the data series used to proxy measures of ICT, followed by analysis of the relationship between the ICT series and real GDP in each country.

1 INTRODUCTION: THE NEW ZEALAND INFOR - MATION ECONOMY

According to The *World Information Technology and Services Alliance* (WITSA) *Digital Planet 2002*, New Zealand has the highest percentage of GDP spent on ICT and experienced a compound annual growth rate of ICT spending of approximately 8.6% in the years 1993-2001, despite the slight decrease in GDP since 1997. The total spending on ICT products and services in New Zealand at the end of 2001 was US$7,164 million, 14.4% of national GDP (*Digital Planet 2002*). In the March 2002 financial year, the total value of the New Zealand ICT industry, excluding telecommunications, was US$7,055 million, 14.2% of GDP.

Regardless of the rapid ICT development and implementation in New Zealand, domestic economic growth does not seem to have a strong correlation with ICT in the period 1993-2001 using the ICT spending data from *Digital Planet 2002* as an approximate measure of the local ICT sector.

1.1 ICT and Economic growth

Regardless of the rapid ICT development and implementation in New Zealand, domestic economic growth does not seem to have a strong correlation with ICT in the period 1993-2001. As in the previous subsection, we use the ICT spending data from *Digital Planet 2002* as an approximate measure of the local ICT sector and plot a scatter diagram against domestic GDP. Figure 1 below, presents a weak short run relationship between log ICT and log GDP with an R^2 value of 0.0493. Such results could be due to the short time period of the available data. Long run and more sophisticated empirical analysis may need to be undertaken before drawing any strong conclusions on the relationship. To build a complete empirical analysis between ICT and economic growth, we need a solid foundation of based upon relevant theoretical models and appropriate data and analysis. In the next section we provide a description of the data summary of relevant economic growth models; their assumptions and frameworks, and their views on how ICT would affect economic growth. This is followed by a review of recent empirical studies and a summary of commonly used ICT series.

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2 DATA

For New Zealand data there are several alternative ICT-related sources as proxies for the local ICT sector including Statistics New Zealand, the Ministry of Economic Development, the Ministry of Education, the Ministry of Maori Development and WITSA's '*Digital Planet*'. Each of the sources provides different measures of the ICT industry. Unfortunately, none provides ICT measures over long time periods, inhibiting causality testing. In this paper we chose two of the most ICT-intensive industries in New Zealand and use their chain volume series as a proxy measure of the New Zealand ICT industry. The two ICT-intensive industries are the *communication service sector* (*LCOM*) and *finance & insurance sector* (*LFIN*). The measure of economic performance used was real Gross Domestic Product (*LGDP*). All series are seasonally adjusted and provided for the period 1987Q2 to 2001Q3 (62 observations) in 95/96 prices. As *LCOM* and *LFIN* are in

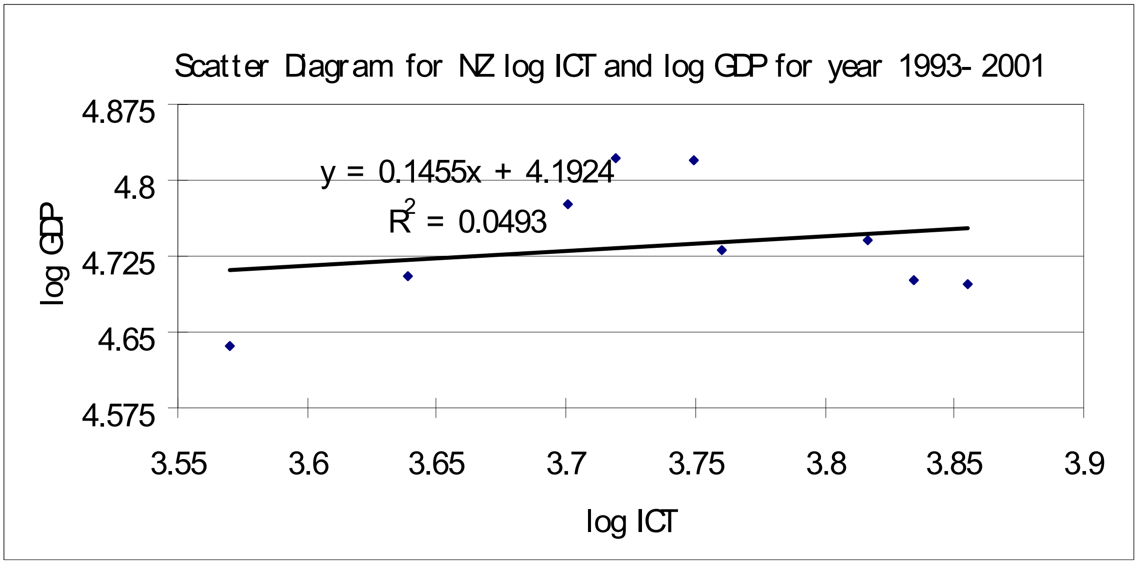

Figure 1: The short run relationship between log ICT and log GDP

the same units, we create a new series of *LCOF* by adding *LCOM* and *LFIN* together. In summary, the log of the alternative ICT series for New Zealand generally experience positive growth over the sample period, and are highly correlated with the log real GDP. However, is such a relationship with GDP sustainable in the long run, or is the relationship spurious? In the next section, we examine these issues by adopting a more sophisticated framework of causality testing, commencing with an introduction to causality testing, followed by an explanation of each stage of the causality testing framework. This is followed by the results for the two countries in section 4.

3 TESTING APPROACHES

One of the traditional ways to test the relationship between two variables is to apply Ordinary Least Square Estimation. Pohjola (2001) regressed GDP growth rates on a number of independent variables and found three knowledge-related variables, education, openness to trade, and the availability of communications infrastructure, positively correlated to GDP growth. Bruinshoodf &Ter Weel (1998) used OLS and found results suggesting a positive correlation between the R&D intensity of a sector and the wage premium of white-collar to blue-collar workers. Morissette & Dolet (1998) found via OLS estimation, that IT application users generate more income than non-users. However, it is important to identify whether these relationships are fundamental of 'spurious'. For this we need to consider the order of integration of the data and the potential for cointegration or spurious regression. As suggested by Lee & Gholami (2001), relying solely on OLS estimation sometimes creates the time series problem of 'spurious regression' which is often neglected or ignored. An approach which removes the spurious regression problem is cointegration estimation.

In an attempt to examine the relationship between ICT and GDP in New Zealand, we adopt a causality testing framework which embodies the cointegration estimation approach. The testing framework consists of three stages, starting with a unit root test that tests the order of integration of the two series. If the results show they are integrated of the same order and that order is at least I(1), cointegration estimation will then be carried out to examine whether the relationship sustains in the long run. If the two series are stationary, the cointegration estimation would only be performed as a verification test for the (low power) unit root test. Lastly, we undertake causality tests that examines the significance of the causal relationship shared among two variables. A detailed step-by-step explanation of each stage is presented in the following three subsections.

3.1 Unit Root Tests

The purpose of the unit root test is to examine the order of integration of a variable. The unit root test used here is based on the Dickey & Fuller (1979). The major disadvantage of the Dickey Fuller unit root test, as suggested by Perron (1989), is that it has a tendency not to reject the null hypothesis of unit root, when the series has a structural break. To determine the potential existence and timing of structural breaks in the series, we apply Zivot and Andrews (1992) test which identifies possible periods of structural break in the time series based upon a series of dummy variable constructs. If the dummy variables are statistically significant, the precise time of the structural break can be determined based on a max R^2 criteria.

3.2 Cointegration Estimation

Following Stage 1 (unit root tests), the next step (where necessary) is to perform cointegration estimation. A linear combination of series integrated of different orders would be integrated to the maximum of orders, except for the case when two or more non-stationary series exactly off-set each other and render a stationary linear combination. This type of series is said to be cointegrated. However, due the lack of power of the Dickey Fuller test, we may be uncertain about the validity of the unit root test results. Thus in all cases we perform the cointegration test as a 'double check/confirmation' of the ADF test results, even when the outcomes show the two series are I(0) or integrated with different orders. If two I(0) series have one significant cointegrating vector then a further check from the unit root test is required. If two significant cointegrating vectors are shared between two I(0) then the unit root result is valid. If the two series are cointegrated with the same order (i.e. both being I(1)), we could expect one or no cointegrating relationship among them. In this case, either one or no significant cointegrating vector should be shared among them. In this analysis we use the Johansen approach.

3.3 Causality Testing

The final step of the causality testing framework is to determine whether a significant causal relationship is shared between the series of interest. Assume series *X* and series *Y* are the time series we are considering and are both I(1) and cointegrated, the test equations for Granger (non)causality would be as follows:

$$Y_t = \alpha_t + \sum_{i=1}^{m} \beta i\, Y_{t-i} + \sum_{j=1}^{n} \gamma j\, X_{(t-j)} + \lambda_1 ECM_{t-1} + u_t \qquad (1)$$

$$X_t = \beta_t + \sum_{i=1}^{q} Bi\, X_{t-i} + \sum_{j=1}^{r} Cj\, Y_{(t-j)} + \lambda_2 ECM_{t-1} + v_t \qquad (2)$$

where the ECM_{t-1} denotes the lagged error correction mechanism term. Equation (1) tests whether series *X* causes series *Y*, and vice versa for equation (2). There are two sets of criteria to test for Granger Causality. Firstly, to test if *X* Granger Causes *Y*:

$$H_0 : \gamma_1 = \gamma_2 = ... \gamma_n = 0$$
$$H_1 : \gamma_1 \neq \gamma_2 \neq .... \gamma_n \neq 0$$

If the test statistics shows the null hypothesis of γ_j being jointly zero is not rejected, *X* does not cause *Y*, unless $\lambda_1 \neq 0$. Then, to test if *Y* Granger Causes *X*, we have:

$$H_0 : C_1 = C_2 = C_3 \ldots \quad C_r = 0$$
$$H_1 : C_1 \neq C_2 \neq C_3 \ldots \quad C_r \neq 0$$

If the null hypothesis of *Cj* is not rejected, *Y* does not causes *X* unless, $\lambda_2 \neq 0$. The length of lags, *m*, *n*, *q*, and *r* could be chosen depending on sample size of the series or using some information criteria test like the Akaike and Schwarz Bayesian Information Criteria. If series *X* and *Y* are I(1) but not cointegrated, we can still test for Granger Causality but use equation (1) and (2) without the ECM terms.

Toda and Yamamoto (1995) developed an alternative causality testing procedure based upon the test equations of Granger, but augmented with extra lags depending on the potential order of integration of the series of interest. If the series are assumed I(1), one extra lag is added to each variable in the test equation. If both variables are assumed I(0), no extra lag is added in the equation, and the Toda Yamamoto test is equivalent to the Granger Causality test. A Wald Test is carried out to determine the relationship between the two variables.

4 EMPIRICAL RESULTS

This section applies the testing methodologies defined above to the three sets of New Zealand ICT variables. The test results of each stage for the three sets of variables are presented in the following three subsections, with a summary of results presented at the end.

4.1 Real GDP (LGDP) and Real Communication Service Volume (LCOM) for period 1987Q2 to 2001Q3

Firstly we examine the relationship between log *real GDP* (*LGDP*) and log *real communication service volume* (*LCOM*) for the period 1987Q2 to 2001Q3. The Augmented Dickey Fuller statistics suggest that both series *LGDP* and *LCOM* are integrated of order one (see Table 1, above). The unit root test equations for both series incorporate a trend component as a likely time trend exists in both time series and the trend variables are significant in the OLS estimations.

The Johansen Estimation supports the Dickey Fuller test results, suggesting the two series are cointegrated and share a significant cointegrating vector. The Granger test statistics shown in Table 1 suggest a significant unidirectional causal relationship from *LCOM* to *LGDP* at the 5% significance level and no significant causal relationship from *LGDP* to *LCOM*. The Toda Yamamoto test adds one additional lag as both series are I(1), and agrees with the Granger test results that a causal relationship is only significant from *LCOM* to *LGDP*, and not vice versa. Note that the AIC and SB information criterions suggest adding one lag variable in the causality test equations.

Table 1: Summary Statistics for *LGDP* and *LCOM*, 1987Q2-2001Q3

Variable: ***LGDP***						
The Unit Root Test:						
Implied order of integration			Statistics	5%	Statistics (trend)	5%
Level			0.11063	-2.915	-2.7941	-3.492
Diff once			-14.6510	-2.195	-15.8021	-3.493
Variable: ***LCOM***						
Implied order of integration			Statistics	5%	Statistic	5%
Level			-1.8743	-2.912	-1.3360	-3.4890
Diff. once			-6.8561	-2.913	-7.4214	-3.4904
The Cointegration Test: Option 4: unrestricted intercept and restricted trend						
VAR=1		Maximum Eigenvalue				Vector 1
H_0:	H_1:	Stat	5%	10%	*LGDP*	(-1.0000)
r=0	r=1	23.79	19.2200	17.18	*LCOM*	(0.51103)
r<=1	r=2	6.05	12.3900	10.55	Trend	(-0.006667)
VAR=1		Trace				
H_0:	H_1:	Stat	5% crit	10%		
r=0	r=1	29.84	25.7700	23.08		
r<=1	r=2	6.05	12.3900	10.55		
The Causality Test 1: Toda & Yamamoto						
H_0: *LGDP* does not cause *LCOM*			CHSQ(1)=0.5850-3E (0.981)	H_1: *LCOM* does not cause *LGDP*		CHSQ(1)=4.6257 (0.031)
The Causality Test 2: Granger						
H_0: *LGDP* does not cause *LCOM*			CHSQ(1)=0.19608 (0.658)	H_1: *LCOM* does not cause *LGDP*		CHSQ(1)=21.8043 (0.0000)

Table 2: Summary Statistics for *LGDP* and *LFIN*

The Unit Root Test: 1987Q2-2001Q3						
Variable: ***LGDP***						
Implied order of integration			Statistics	5%	Statistics (trend)	5%
Level			0.11063	-2.915	-2.7941	-3.492
Diff once			-14.6510	-2.195	-15.8021	-3.493
Variable: ***LFIN***						
Implied order of integration			Statistics	5%	Statistic (trend)	5%
Level			1.2092	-2.9137	-2.3751	-3.4904
Diff. once			-5.6709	-2.9147	-7.4512	-3.4919
The Cointegration Test: Option 2: restricted intercept and no trend						
VAR=2		Maximum Eigenvalue				Vector 1
H_0:	H_1:	Stat	5%	10%	*LGDP*	(-1.0000)
r=0	r=1	24.09	15.8700	13.81	*LFIN*	(0.72031)
r<=1	r=2	4.022	9.1600	7.530	Inter	(4.8715)
VAR=2		Trace				Vector 2
H_0:	H_1:	Stat	5% crit	10%	*LGDP*	(-1.0000)
r=0	r=1	28.12	20.18	17.88	*LFIN*	(0.99700)
r<=1	r=2	4.022	9.1600	7.530	Inter	(3.0112)
The Causality Test 1: Toda & Yamamoto						
H_0: *LGDP* does not cause *LFIN*			CHSQ(1)=1.7024 (0.129)	H_1: *LFIN* does not cause *LGDP*		CHSQ(1)=7.7098 (0.05)
The Causality Test 2: Granger						
H_0: *LGDP* does not cause *LFIN*			CHSQ(1)=0.35507 (0.551)	H_1: *LFIN* does not cause *LGDP*		CHSQ(1)=12.5182 (0.000)

Table 3 : Summary Statistics for *LGDP* and *LCOF*

The Unit Root Test: 1987Q2-2001Q3						
Variable: **LGDP**						
Implied order of integration			Statistics	5%	Statistics (trend)	5%
Level			0.11063	-2.915	-2.7941	-3.492
Diff once			-14.6510	-2.195	-15.8021	-3.493
Variable: ***LCOF***						
Implied order of integration			Statistics	5%	Statistic	5%
Level			3.9681	-2.9127	-1.5334	-3.4890
Diff. once			-4.6616	-2.9137	-6.3934	-3.4904
The Cointegration Test: Option 3: unrestricted intercept and no trend						
VAR=2		Maximum Eigenvalue				Vector 1
H_0:	H_1:	Stat	5%	10%	*LGDP*	(-1.0000)
r=0	r=1	26.30	14.8800	12.98	*LCOF*	(0.40751)
r<=1	r=2	6.267	8.0700	6.500		
VAR=2		Trace				Vector 2
H_0:	H_1:	Stat	5% crit	10%	*LGDP*	(-1.0000)
r=0	r=1	32.57	17.8600	15.75	*LCOF*	(0.76782)
r<=1	r=2	6.257	8.0700	6.500		
The Causality Test 1: Toda & Yamamoto						
H_0: *LGDP* does not cause *LCOF*			CHSQ(1)=0.57210 (0.811)	H_1: *LCOF* does not cause *LGDP*		CHSQ(1)=6.8392 (0.09)
The Causality Test 2: Granger						
H_0: *LGDP* does not cause *LCOF*			CHSQ(1)=0.45153 (0.502)	H_1: *LCOF* does not cause *LGDP*		CHSQ(1)=25.2118 (0.0000)

4.2 Real GDP (LGDP) and Real Finance and Insurance Volume (LFIN) for period 1987Q2 to 2001Q3

For the pair *Real GDP* (*LGDP*) and *Real Finance and Insurance Volume* (*LFIN*), 1987Q2 to 2001Q3, we add a trend variable to the Dickey Fuller equation as the trend component is significant in the OLS regression. The Augmented Dickey Fuller test statistics suggests series *LFIN* to be cointegrated of order one (Table 2). As shown in Table 2 the Johansen Estimation suggests a cointegrating relationship shared between the two series is significant at the 5% level. We then perform the causality test as the final stage of the testing methodology. The causality tests show similar outcomes to those of section 4.1. The Granger test suggests a significant relationship from *LFIN* to *LGDP*, but not the reverse at the 5% confidence level. The Toda Yamamoto test with one extra lag variable added, agrees with these results, with only the coefficients of the causal variable for *LFIN* causing *LGDP* statistically significant at the 5% level.

4.3 Real GDP (LGDP) and Real Communication Service, Finance and Insurance (LCOF) 1987Q2 to 2001Q3

In this section we test the relationship between *LCOF* and *LGDP* for the period 1987Q2 to 2001Q3. One significant trend variable is added to the unit root test equation for *LCOF* as there appears to be an upward trend in the time series graph and the slope of the trend variable is statistically significant different from zero at the 5% level. We also include one extra lag in the Dickey Fuller test equation. The unit root test result shows the series *LCOF* is integrated of order 1. The summary statistics of this subsection are presented as Table 3.

LGDP and *LCOF* could share one or no cointegrating vector since they are both integrated with order 1. The Johansen Cointegration Estimation shows one significant cointegrating variable, suggesting the two variables share a long term equilibrium relationship and the difference between the two series is constant in the long run.

The Granger and the Toda Yamamoto causality tests provide the same outcome that a causal relationship from *LGDP* to *LCOF* is rejected, but from *LCOF* to *LGDP* is statistically significant at the 5% and 10% level.

4.4 Summary of results

Table 4 provides a summary of the findings in this chapter. All results from the causality test suggest a causal relationship from alternative ICT variables to *LGDP* at the

Table 4: Summary of Causality Test Results

Time period	Methodology	Results
1987Q2 to 2001Q3	Granger	*LCOM⇒LGDP*
	Toda Yamamoto	*LCOM⇒LGDP*
1987Q2 to 2001Q3	Granger	*LFIN⇒LGDP*
	Toda Yamamoto	*LFIN⇒LGDP*
1987Q2 to 2001Q3	Granger	*LCOF⇒LGDP*
	Toda Yamamoto	*LCOF⇒LGDP*#

5% and no significant opposite-directional causal relationship. Note that all causal relationships shown in the table are significant
at the 5% level except the one with the '#' sign.

The results presented here generally show a significant causal relationship from *LGDP* to ICT series rather than from ICT to *LGDP*, for the sample period of 1987Q2-2001Q3.

5 CONCLUSIONS

Aggregate global real GDP has increased over the last decade, whereas the distribution of income has remained unevenly spread across geographical regions and between countries. North America, Europe and a few newly industrialized countries continue to dominate the world with ninety percent of total real income. Has the development of ICT had something to do with the growth of GDP?

Simple correlation generally found evidence supporting ICT and economic growth in New Zealand sharing a significant relationship. Moving to causality testing analysis, previous results have found little support for the relationship between the two variables across countries. The results presented here from New Zealand suggest that, over a very short and limited time period, ICT appears to cause GDP and not vice versa.

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