Estimating components of ICT expenditure: a model-based approach with applicability to short time-series

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Forecasting Components of ICT Expenditure: A Model-Based Approach with Applicability to Short Time-Series*†

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Abstract

This paper develops a microeconomic model-based approach to forecast national information and communications technology expenditure that is helpful when only very short time-series are available. The model specification incorporates parameters for network effects and national e-readiness. Finally, the model allows for observed non-homotheticity and 'noise' found in sample data, with the latter attributed to country-specific influences.

JEL Classification: C51, C53, L96
Keywords: ICT forecasts, short time-series, microeconomic modeling

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1. Introduction

There is a consensus view that, since the mid-1990s the US has created a 'New Economy' based on the rapid deployment and widespread utilization of new information and communications technology (ICT) and by advances in computing and information management that caused a structural acceleration in labour productivity and output growth (Jorgenson and Stiroh 2000, Salvatore 2003).[1] The term New Economy is intended to capture contribution of new ICT to non-inflationary growth and high employment that characterized the period (Jorgenson and Wessner 2002). Innovation, in particular, the rapid rate of technological innovation in ICT and the rapid growth of the Internet, are seen as underpinning such productivity gains (Jorgenson and Wessner 2002). These gains are derived from greater efficiency in the production of computers and from the expanded use of ICT (Onliner and Sichel 2000).

Although the New Economy is a macroeconomic phenomenon, its underlying dynamics combined elements of technological innovation, structural change and public policy (Jorgenson and Wessner 2002). Clearly, reliable long-term diffusion ICT forecasts, and that of enabling network technology more generally, are an indispensable aid for planning and strategy (Makridakis 1996). Reliable forecasts allow firms to initiate appropriate investment and production plans, and government to better apply public policy. To succeed in forecasting, econometric models have to mimic the adaptability of best forecasting devices, while retaining their foundations in economic analysis (Clements and Hendry 2003). Important economic features of

[1] The definition of ICT adopted by the OECD ICCP panel of statistical experts is that it is the set of

networks that must be included in convincing ICT forecasting models are strong complementarity among network components, and the presence of consumption and production externalities (Shy 2001). However, standard linear (fixed effect, random effect, random coefficient and cross-sectional varying) and non-linear (diffusion) models are not typically motivated by the economic theory of networks (for a review see, Madden et al. 2002). Also, commonly used forecasting models need long time-series to obtain reliable parameter estimates, and typically require sample data to cover any inflection point (Islam et al. 2002). As such, these models are not well suited to forecasting new ICT diffusion.

This study explicitly models network effects and provides for the likelihood of non constant parameter estimates occurring at stages of ICT network maturation. In doing so, the study provides an approach designed to estimate economically meaningful parameters of ICT adoption forecasts based on theoretical microeconomic foundations. The modelling also recognizes that the extent of benefit derived from progress in ICT innovation depends on national readiness to adopt e-commerce and exploit efficiency gains (Black and Lynch 2001). Finally, the model specification allows for observed non-homotheticity and 'noise' in these data, with the latter attributed to country-specific influences.

To construct a model of ICT expenditure component choice by business or households this study focuses on conditional decision-making. That is, the approach enables parameter estimates from an instantaneous objective function for a representative consumer-firm to be estimated. The parameter estimates form the basis

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activities that facilitate by electronic means the processing, transmission and display of information.

of ICT expenditure component historical simulations.[2] Of the estimated share equations, six are ICT expenditure components—the seventh is for the rest of GDP. The equations are viewed as either consumer or producer input demands, or a combination of both. An indirect utility function, defined on nominal GDP and prices of the seven 'goods' is employed to demonstrate that, conditional on nominal GDP, the ICT component and residual good expenditure shares are optimally chosen.[3]

Further, the empirical concern of the paper is the nations of Brazil, Canada, Mexico and the United States. The rationale for this focus is that these countries are among 24 nations that have agreed to create the Free Trade Area of the Americas (FTAA), in which the barriers to trade and investment will progressively be eliminated, by 2005. The United States is the economically dominant member of the North American Free Trade Agreement (NAFTA also includes Canada and Mexico). Brazil is by far the largest economy in South America and ranked roughly 10th among the world's economies. With the integration of these economies the role of the New Economy is potentially important.

The paper is organised as follows. Section 2 describes a 55 country, 9 year data set that concerns annual national ICT component expenditure. Section 3 specifies a share equation model for estimation. Section 4 reports econometric estimates and presents a historical simulation. Section 5 contains suggestions for model extensions.

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[2] Forecasting is limited to within sample historic simulations due to the limited degrees of freedom available for estimation.

[3] The equilibrium value of nominal GDP in the full model is endogenous and determined from constrained maximisation of inter-temporal utility. That is, subject to production-investment-

2. Data

The World Information Technology and Service Alliance (WITSA) publish the *Digital Planet 2002* data base that contain annual telecommunications and information technology (IT) expenditure data on 55 countries for the period 1993-2001. Table 1 lists Digital Planet 2002 total ICT expenditure data for Brazil (Country 5), Canada (Country 7), Mexico (Country 28) and the United States (Country 53). Also contained in Table 1 are data for the IT expenditure components: telecommunications (TELE), internal (ITInt), office equipment (ITOE), software (ITSoft), hardware (ITHard) and services (ITServ). Additionally, GDP in current United States dollars (US$) in millions and population in millions are contained therein.

For estimation ICT expenditure by category is expressed as a GDP share. This procedure defines 6 ICT expenditure shares and a 'rest of GDP' category. The most rapidly growing expenditure component for low-income countries is ITHard. By contrast, most high-income country IT expenditure growth occurs for ITServ component. These growth differentials reflect shifting input shares and suggest non-linearity along expenditure share expansion paths with rising national income. This, non-homotheticity of preferences or technology is revealed in Fig. 1(a) through Fig. 1(d) where different growth trends are clearly apparent. In Fig. 1(a) (United States) and Fig. 1(b) (Canada), ITServ (dashed line) is rising more rapidly than ITHard (solid line). Since 1998, the ITHard share monotonically declines for both the United States and Canada, whereas the ITServe share increases through the sample period. By 2001,

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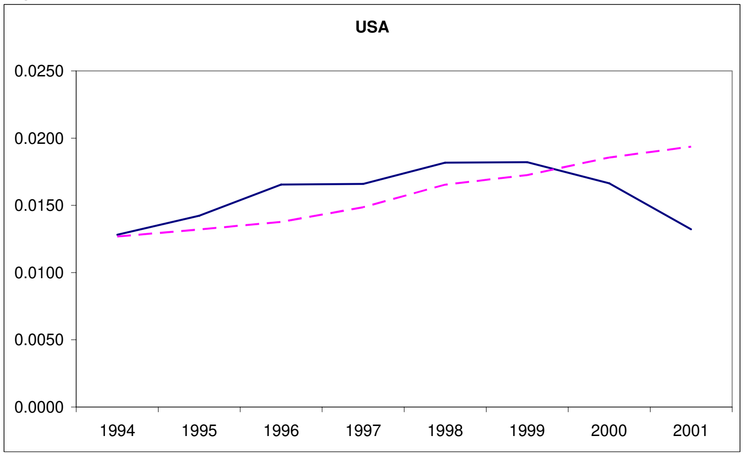
consumption trade-offs.

ITServ dominates ITHard in terms of GDP share. Conversely, for low-income countries, ITHard has the larger GDP share. However, while both ITServ and ITHard GDP shares are increasing for Brazil, the Mexico expenditure shares are stagnant. To enable calculation of common technology and preference parameters requires allowance for observed non-homotheticity in the model specification.

Table 1: ICT Expenditure and Selected Statistics, 1993-2001

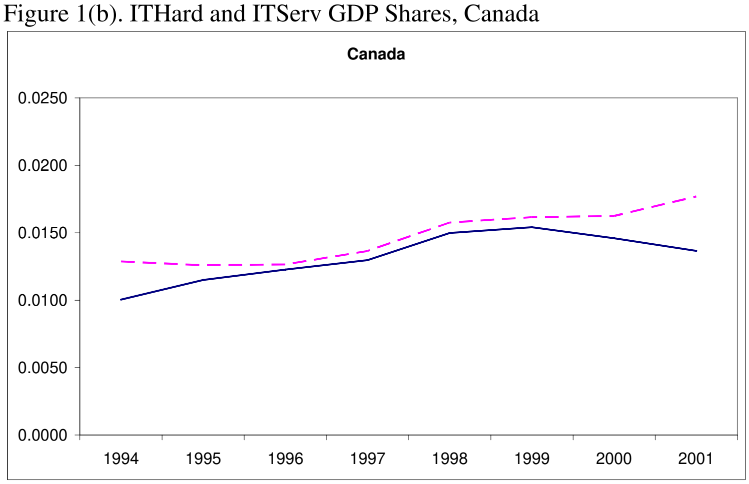
	ICT	TELE	ITInt	ITOE	ITSoft	ITHard	ITServ	GDP	Pop
Brazil									
1993	15488	7891	2375	261	467	2505	1989	442514	151.5
1994	14567	5984	2482	316	647	2895	2243	539519	153.7
1995	18882	9696	2585	394	856	2891	2460	699333	155.8
1996	25968	13924	2680	457	1084	5044	2779	786909	157.9
1997	33897	20109	2698	542	1389	5991	3168	807071	159.9
1998	38732	22601	3181	592	1569	6549	4240	790449	165.9
1999	46008	30339	3380	523	1635	5782	4349	528828	168.0
2000	49396	31364	3414	645	1749	7140	5084	588048	171.2
2001	50031	31703	3583	623	1863	6891	5368	602783	174.4
Canada									
1993	37908	12785	10383	553	2055	5311	6821	565791	28.9
1994	39536	13584	10195	620	2196	5674	7267	564800	29.0
1995	41166	13916	9989	603	2484	6763	7411	588086	29.4
1996	44059	15177	9871	680	3080	7508	7743	611931	29.7
1997	47458	16648	9792	742	3433	8206	8637	632773	30.0
1998	50839	17279	10023	820	4109	9070	9538	605226	30.3
1999	55345	19232	10124	896	4782	9914	10397	643547	30.5
2000	58831	20386	10401	924	5517	10224	11379	700369	30.8
2001	60896	21266	10865	864	5958	9558	12385	699954	31.1
Mexico									
1993	13774	9068	1448	177	370	1695	1016	405118	91.2
1994	14995	9897	1454	205	401	1873	1165	416528	92.5
1995	10620	7205	1343	104	234	1098	636	287027	93.8
1996	12866	7873	1909	165	336	1825	758	329897	95.1
1997	14257	8389	1943	205	428	2267	1025	396028	95.4
1998	14534	8052	2097	215	494	2377	1299	415257	95.8
1999	16198	8930	2171	249	533	2751	1564	476412	96.6
2000	18386	10166	2188	302	610	3340	1780	574563	97.3
2001	19210	10806	2326	300	597	3316	1865	600313	98.0
United States									
1993	484993	181331	102599	4661	33020	80965	82417	6643740	258.1
1994	518492	195166	101767	5169	37780	89792	88818	7006649	260.6
1995	557252	205577	100787	6458	40669	105670	98091	7430027	263.0
1996	599572	209587	99410	7639	46802	128874	107260	7786649	265.5
1997	642798	220067	98515	7582	54010	138611	124013	8348026	267.9
1998	719724	231070	110088	8724	65250	159477	145115	8777122	270.4
1999	761863	242623	105522	9255	75006	169186	160271	9291012	272.9
2000	805857	252328	103421	9051	90969	165470	184618	9948852	275.4
2001	812634	265954	107428	7442	96556	136051	199203	10286506	277.9

Figure 1(a). ITHard and ITServ GDP Shares, United States



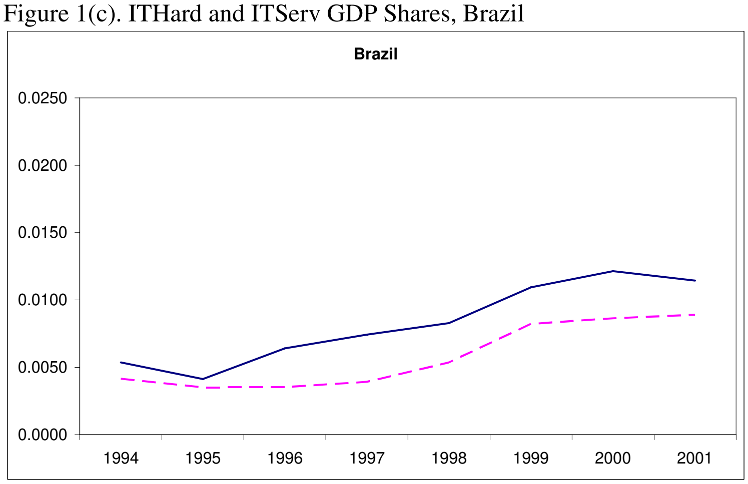
Note: ITHard is the solid line; ITServ is the dashed line.

Figure 1(b). ITHard and ITServ GDP Shares, Canada



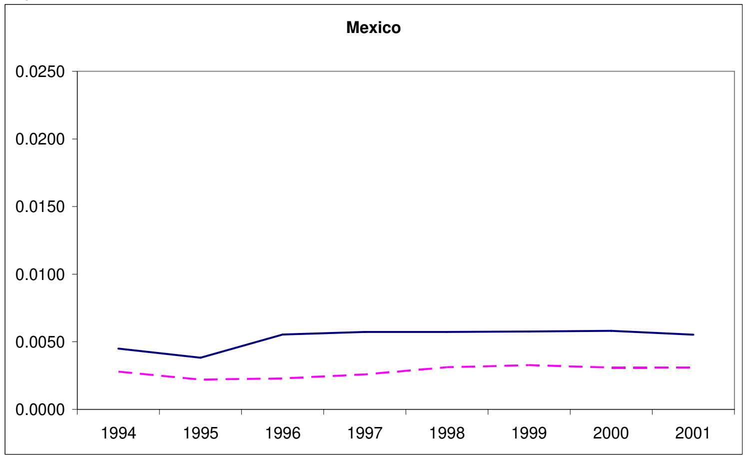
Note: ITHard is the solid line; ITServ is the dashed line.

Figure 1(c). ITHard and ITServ GDP Shares, Brazil



Note: ITHard is the solid line; ITServ is the dashed line.

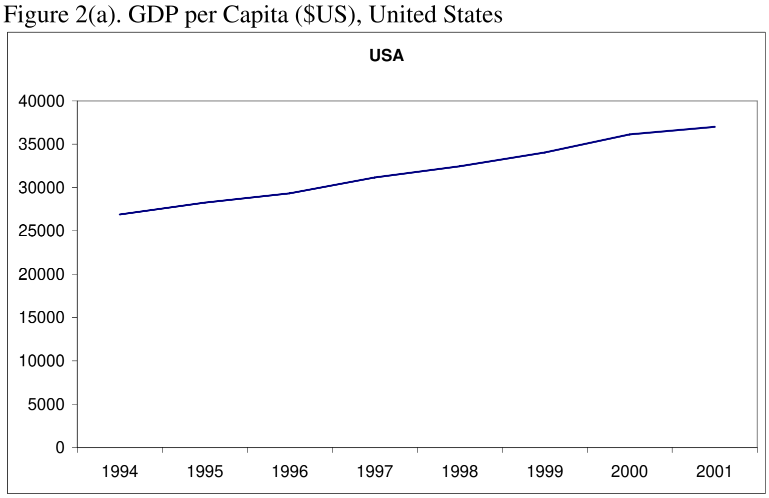
Figure 1(d). ITHard and ITServ GDP Shares, Mexico



Note: ITHard is the solid line; ITServ is the dashed line.

Table 1 also indicates substantial differences in GDP and by implication in GDP per capita. The differences are most readily apparent in Fig. 2(a) through Fig. 2(d), which graph per capita GDP (in US$) using data from the last two columns of Table 1.[4]

Figure 2(a). GDP per Capita ($US), United States



[4] In this study comparative values are always reported in US$, reflecting the global reach of ICT and that the United States is a major source of ICT products.

Figure 2(b). GDP per Capita ($US), Canada

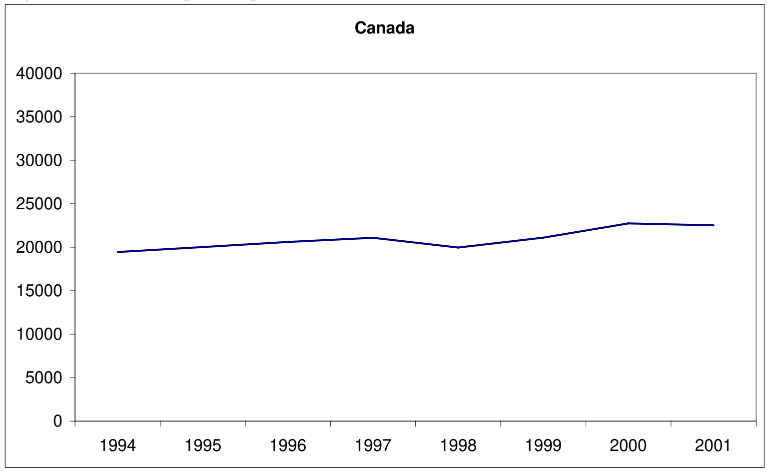


Figure 2(c). GDP per Capita ($US), Brazil

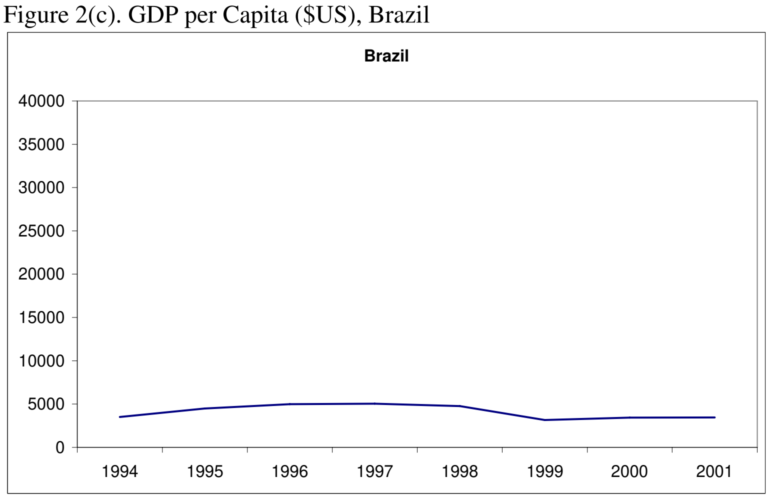
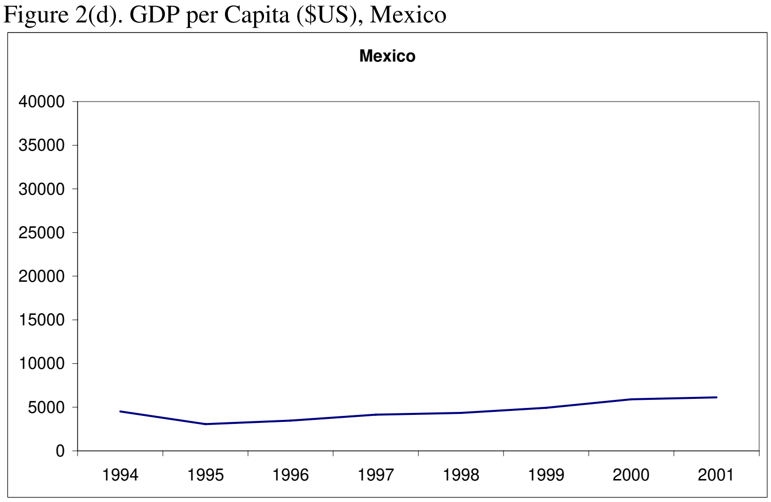


Figure 2(d). GDP per Capita ($US), Mexico



Finally, Fig. 3(a) through Fig. 3(h) presents the sample of 53 countries for 1994-2001 by variable, sorted in ascending order of the logarithm of per capita GDP. The 'noise' in these data, probably due to country-specific influences, also needs to be addressed by the model specification.

Figure 3(a). TELE Share by Log GDP, Full Sample

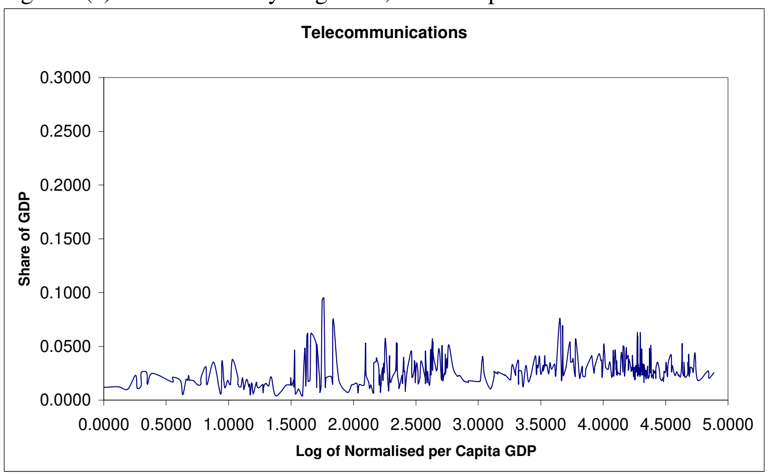


Figure 3(b). ITInt Share by Log GDP, Full Sample

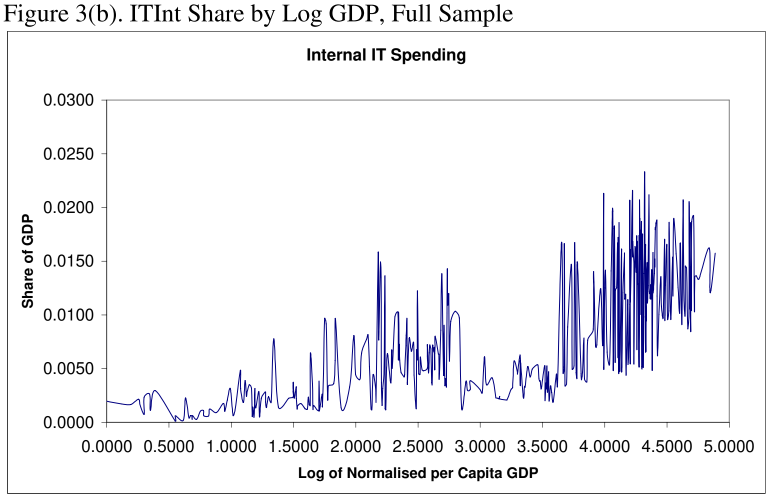


Figure 3(c). ITOE Share by Log GDP, Full Sample

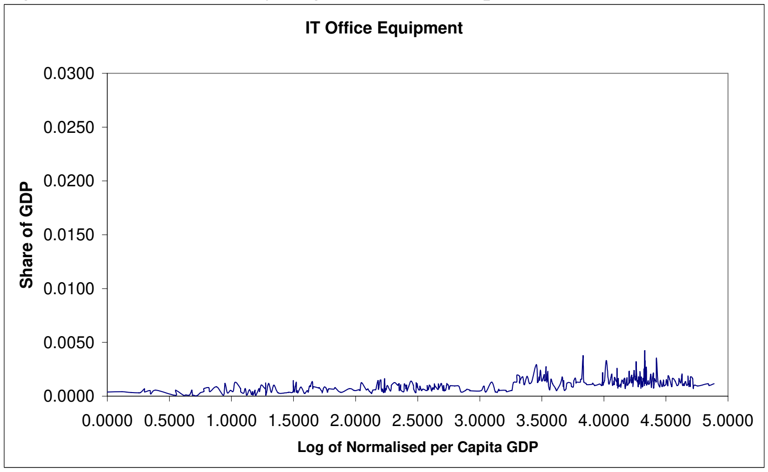


Figure 3(d). ITSoft Share by Log GDP, Full Sample

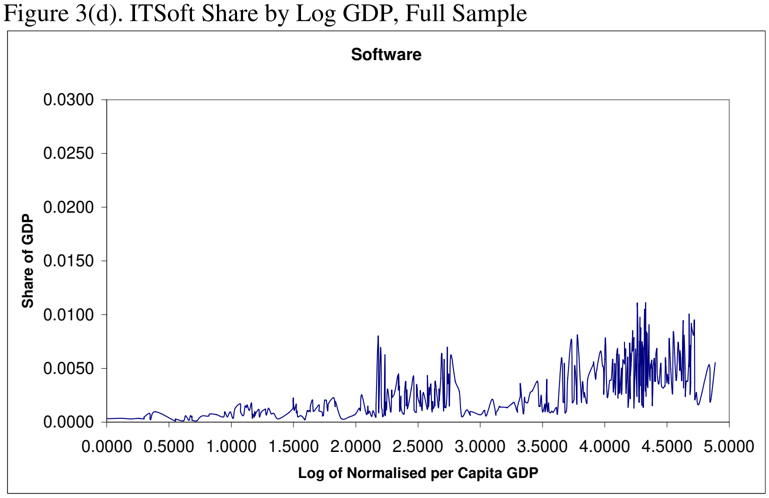


Figure 3(e). ITHard Share by Log GDP, Full Sample

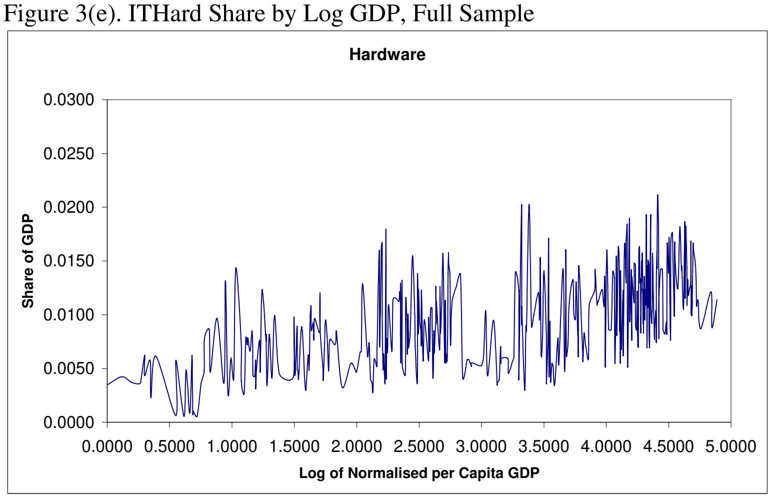


Figure 3(f). ITServ Share by Log GDP, Full Sample

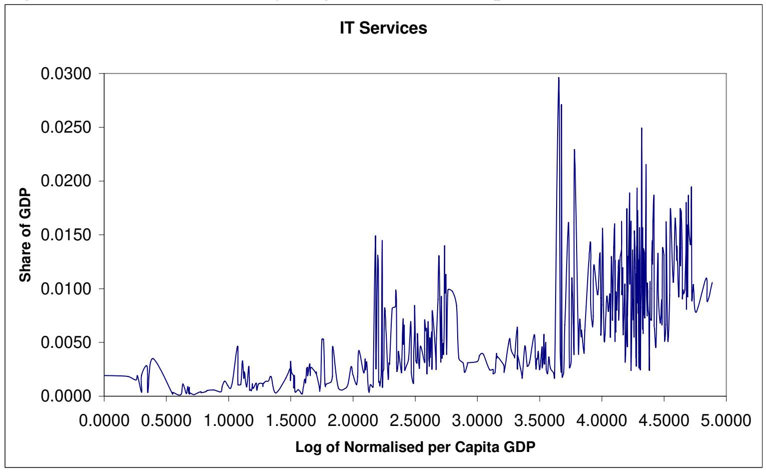


Figure 3(g). Rest of GDP by Log GDP, Full Sample

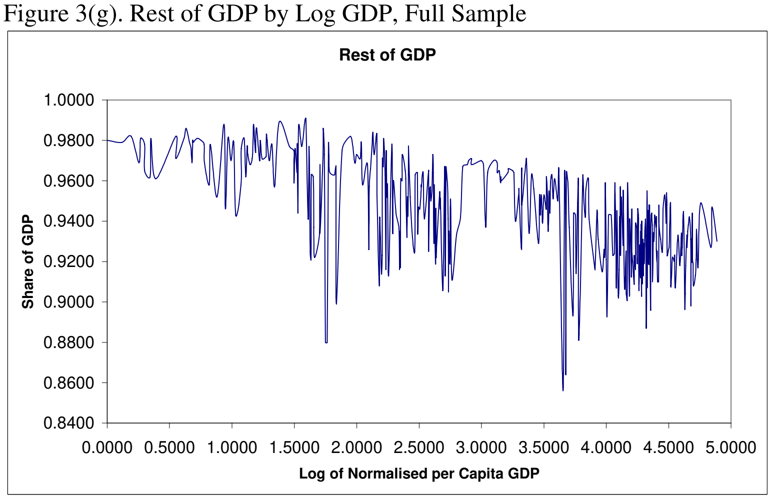
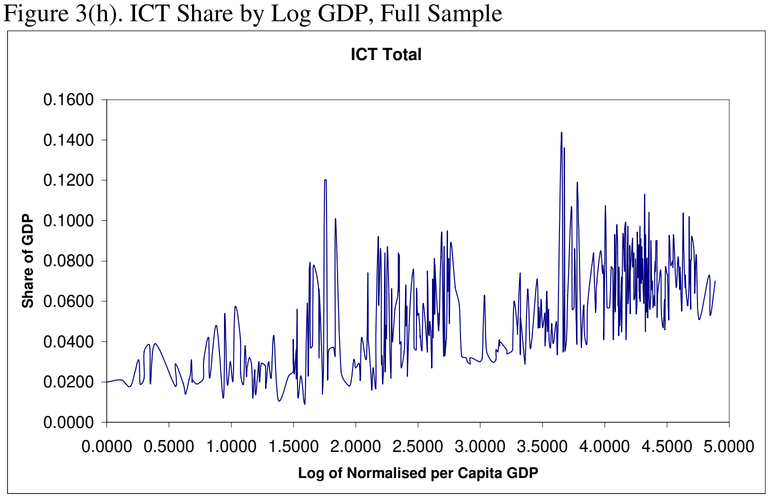


Figure 3(h). ICT Share by Log GDP, Full Sample



3. Model Specification

An expenditure share model is applied at a national macro level to 53 countries within a representative agent paradigm. That is, the model is compatible with the behavior of a stochastic inter-temporal utility maximizing agent faced with a national investment-production-consumption constraint. Time-separability is assumed to allow the agent to optimize in stages. Namely, the agent allocates a given potential GDP to production, consumption (of TELE, ITInt, ITOE, ITSoft, ITHard, ITServ) and the remainder of GDP. In particular, the representative agent maximizes instantaneous utility given the GDP allocation and component prices. Whilst an abstraction, this program captures the notion that allocations arise from a process of optimization subject to constraint.[5]

A convincing instantaneous indirect utility specification must capture the stylized facts revealed by the data in Section 2. First, the utility specification should at the very least allow for observed non-homotheticity. The Almost Ideal Demand (AID) System is a share equation system that allows for non-homotheticity by expressing indirect utility as a function of money (nominal GDP) and two price indexes. Deaton and Muellbauer (1980), derive the AID share system,

$$s_i = \alpha_i + \beta_i \left\{ \ln c - \left[\sum_k \alpha_k \ln p_k \right] \right\}, \tag{1}$$

by applying Roy's identity to the indirect utility specification:

[5] At an inter-temporal level, GDP allocations are made to maximise the present value of an expected utility stream. That is, GDP is endogenous and depends on underlying resources (capital). This study focuses on the optimal allocation of components of GDP among ICT and non-ICT products, and the maximal instantaneous utility this generates on the assumption that, whatever the decision as to how much GDP is available at any time, the allocation decision is then optimal.

$$U(c,p)=\frac{1}{B(p)}\ln\left(c/A(p)\right), \tag{2}$$

where c is nominal GDP, $s_i \equiv p_i q_i / c$ is the share of the i^{th} category comprising GDP, p_k is price of category k and the price indexes are:

$$\ln A(p)=\sum_k \alpha_k \ln p_k, \quad \sum_k \alpha_k = 1 \tag{3}$$

and

$$\ln B(p)=\sum_k \beta_k \ln p_k, \quad \sum_k \beta_k = 0\,. \tag{4}$$

$B(p)$ in (2) induces non-homotheticity in the shares. To see this, note that in (1) when $\beta_i = 0$ the constant shares $s_i = \alpha_i$ result.

Econometric estimation of (1) provides values for price index parameters α_k and β_k for $k = 1,...,n$. However, parameter estimates are still obtainable when price data are not available or incomplete. In this situation an aggregate deflator $\bar{A}$ is used as a proxy for term in square brackets in (1), viz.

$$s_i = \alpha_i + \beta_i \ln(c/\bar{A}) \tag{5}$$

where $c/\bar{A}$ is real GDP. With some loss in efficiency α_i and β_i are estimable via (5) with $\bar{A}$ treated as data.[6] The α_i are interpreted as price index weights for the GDP

[6] As complete price data for the 53 country 9 year expenditure shares are not available $\bar{A}$ is set at unity, and c is a proxy for $c/(A(p))$ in estimation. With short series, proxying real by nominal GDP is

deflator when GDP is low (for an 'Old Economy'). That is, with sample data scaled so that $\ln(c/\overline{A})=0$ for the lowest level of GDP, the α_i are shares for the reference country and time (India in 1994). Additionally, other sample country β_i represents 'corrections' as an economy grows and adjusts toward New Economy status.

Second, the noise in the sample data due to country-specific influences requires additional parameters be introduced to the utility specification.[7] In particular, specify:

$$s_i = \frac{\alpha_i + \theta\beta_i \ln\left(c/A(p)\right)}{1+\theta\ln\left(c/A(p)\right)}, \tag{6}$$

which is derived from the indirect utility function,

$$U(c,p) = \left(\frac{c}{B(p)}\right)^{\theta} \ln\left(c/A(p)\right), \quad \theta > 0 \tag{7}$$

where the price indexes A and B are as defined by (3) and (4), but with $\sum\beta_i = 1$.[8] θ is a country-specific indicator of national e-readiness (pervasiveness of ICT). The β_i are now interpreted as long-run shares as $\ln(c/A(p)) \to \infty$. However, this degree of e-readiness and hence the speed of transition is likely to change through the sample period.

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not too inaccurate. However, a later specification effectively estimates a fractional rather than log-linear system. This specification modifies the role of GDP trends on model structure to reduce any error introduced through the procedure.

[7] In principle, under (5) this situation could be handled by allowing β_i to be made country specific. However, this procedure is not practical when there are only short country time series available.

[8] Application of Roy's identity to (7) provides (6). Specification (7) is the Modified Almost Ideal Demand System due to Cooper and McLaren (1992).

Accordingly, to capture national transition from Old Economy to New Economy, the indirect utility function (7) is further modified:

$$U(c,p)=\left(\frac{c}{B(p)}\right)^{\zeta-\phi}\left(\frac{c}{A(p)}\right)^{\phi-\eta}\ln\left(c/A(p)\right).\quad \eta<\phi<\zeta \tag{8}$$

Specification (8) acknowledges a contribution of both the Old Economy price index $A(p)$ and asymptotic New Economy price index $B(p)$ so as to allow the degree of non-homotheticity to vary by national e-readiness. In particular, ϕ is specified as a variable parameter that is 'close' to ζ for an Old Economy and falls toward η as the degree of e-readiness increases and the country asymptotes toward New Economy status. At the same time, η is allowed to be country specific. For a 'near' New Economy η is relatively high, and ϕ does not have to fall as far to eliminate the influence of the Old Economy price index $A(p)$ in the non-homotheticity correction. Specifically ϕ is defined by,

$$\phi=\zeta+(\eta-\zeta)Y \tag{9}$$

where Y is a measure of e-readiness that uses the United States as the benchmark. Y is zero for the reference country and year with lowest per capita GDP (India in 1994), and has a strictly unattainable upper bound of unity. For country j in period t, the measure is last period's ICT/GDP relative to base and benchmark cases:

$$Y_{t,j} = \frac{ICT_{t-1,j} / GDP_{t-1,j} - ICT_{1993,India} / GDP_{1993,India}}{ICT_{t-1,USA} / GDP_{t-1,USA}} . \qquad (10)$$

By (9), for the worst case scenario (India in 1994) ϕ equals ζ making the New Economy index $B(p)$ irrelevant in (8). With improved e-readiness ϕ falls toward η. The speed of the fall increases with the degree of national e-readiness. Given (8), by Roy's identity the modified share system is:

$$s_i = \frac{\alpha_i + \left[(\zeta - \phi)\beta_i + (\phi - \eta)\alpha_i\right] \ln\left(c / A(p)\right)}{1 + (\zeta - \eta)\ln\left(c / A(p)\right)} . \qquad (11)$$

Finally, the functional form of the Old Economy price index A in the logarithmic part of (8) is amended to allow for path dependence and ICT network effects. That is, expenditure shares can sluggishly adjust with an adjustment speed dependent on past expenditure shares, and that decisions on optimal shares are influenced by the size and sophistication of the network. The generalized indirect utility function is:

$$U(c,p) = \left(\frac{c}{B(p)}\right)^{\zeta-\phi} \left(\frac{c}{A(p)}\right)^{\phi-\eta} \ln\left(c / A^*(p,c,s_{-1})\right), \quad \eta \le \phi \le \zeta \qquad (12)$$

where

$$\ln A^*(p,c,s_{-1}) = \ln A(p) + \sum_k \gamma_k \left[s_{k,-1} - s_{\underline{k}}\right] \ln(p_k / c) . \qquad (13)$$

The $s_{k,-1}$ are lagged expenditure shares for category k, $s_{\underline{k}}$ is the 1993 share and s_{-1} is the vector of lagged shares. The corresponding optimal expenditure share equations are:[9]

$$s_i = \frac{\alpha_i + \gamma_i\left[s_{i,-1} - s_{\underline{i}}\right] + \left[(\zeta - \phi)\beta_i + (\phi - \eta)\alpha_i\right]\ln\left(c / A^*(p,c,s_{-1})\right)}{1 + \sum_k \gamma_k\left[s_{k,-1} - s_{\underline{k}}\right] + (\zeta - \eta)\ln\left(c / A^*(p,c,s_{-1})\right)}. \tag{14}$$

Equations (14) mop up autocorrelation via the lagged shares. The specification also introduces several parameters that have useful interpretations. ζ measures the innovative quality of ICT in a global context, while the country-specific parameters η allow for peculiar national institutional features—such as degree of microeconomic flexibility—which may affect the adoption of innovative technology. Finally, the time-varying parameter ϕ allows for the degrees of national e-readiness.

4. Estimation and Model Validation

With 1993 data used to construct initial lagged shares, estimation is undertaken on the 1994-2001 sample data. Further, because Country 32 (Other Asia Pacific) and Country 55 (Vietnam) are unsuitable as representative countries their data are excluded for estimation, viz. estimations are performed on variables from 53 countries pooled across 8 estimation years.[10] While estimation is based on a global sample of

[9] Share equations (14) are optimal from the perspective of a private representative agent. That is, while lagged shares and total expenditure influence price index A^*, the private agent is assumed not to recognise this as depending on individual decisions. A divergence between private and social optimum can occur. As interest is focused on estimating parameters associated with actual behaviour the private optimum share allocation is tracked. Model consistent equilibrium is imposed by aligning c and s_{-1} in A^* with their equivalent values in other components of (14).

[10] The estimation approach is based on a functional form that exhibits desirable 'effectively globally regular' characteristics—provided real GDP is normalised at the lowest sample value of GDP at the

nations, the reporting concentrates on findings for Brazil, Canada, Mexico and the United States. Due to a lack of compatible price data, for estimation real GDP is replaced by nominal GDP. As nominal GDP appears in both the numerator and denominator, and because the time-series modeled are short, any distortion from using proxy data is probably minimal. SHAZAM Version 9.0 estimates 6 of 7 share equations jointly as a nonlinear system. The allowance for non-homotheticity in the specification is relied on to justify pooling these data cross country. Table 2 shows that the parameters $\alpha_2,...\alpha_7$ are estimated with precision. Note, that the estimated value for α_1 is determined residually by adding up, viz. the expenditure shares must sum to unity. The α_i are predicted shares for the reference country and time, viz. India in 1994. Alternatively, the β represent the estimated limiting ICT expenditure shares associated with the technology or preferences when real GDP becomes very large. That is, when new ICT completely permeates the economy—at this point ϕ falls to η. ϕ has a maximum value of $\zeta = 1.047$ (the least national e-preparedness for any country contained in the sample) for India in 1994, and falls with speeds driven by particular national e-readiness toward a country-specific lower bound, η. The fit of the share equations and apparent randomness of residuals is improved by inclusion of the γ parameters. Comparison of α_7 with β_7 estimates indicate that ICT expenditure as a share of GDP rises from around 2% of GDP for a low-income (Old Economy) country to near 8% in the long run for a high-income (New Economy) country.[11]

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base year. For this data set, Vietnam and Other Asia-Pacific have the lowest GDP at 1994. However, neither country is representative enough, even among developing countries, to provide a sensible base for normalisation. After removing Vietnam and Other Asia-Pacific data from the sample, India is chosen for normalisation. For further explanation of the effective global regularity condition, see Cooper and McLaren (1996).

[11] This interpretation is based on extrapolations using the estimated curvature of the Engel curves.

Table 2: Parameter Estimates

Parameter	Estimate	t-stat
α_1	0.0119	
α_2	0.0019	24.6
α_3	0.0003	20.7
α_4	0.0003	8.4
α_5	0.0033	28.8
α_6	0.0015	15.7
α_7	0.9808	2026.5
β_1	0.0404	
β_2	0.0094	7.9
β_3	0.0008	3.9
β_4	0.0026	3.5
β_5	0.0102	6.1
β_6	0.0166	13.1
β_7	0.9202	106.8
γ_1	0.969	29.8
γ_2	0.954	34.1
γ_3	0.927	28.1
γ_4	1.055	31.6
γ_5	0.918	30.5
γ_6	1.029	43.5
γ_7	1.875	9.7
ζ	1.047	7.6

Note: α_1 (resp. β_1) is determined residually by the constraint $\sum_{k=1}^{7}\alpha_k = 1$ ($\sum_{k=1}^{7}\beta_k = 1$).

The country-specific η parameters are reported in Table 3. For the specification employed, the inequality $\eta < \zeta$ must hold to ensure positive marginal utility for all $c > 1$, i.e., effectively global as c is normalized to unity for India in 1994. Given ζ is estimated at 1.047, this condition is violated for China, Columbia, France, Greece, Ireland, Other Eastern Europe, Portugal and South Africa. Note the η value for Brazil is 1.011, for Canada is 1.037, for Mexico is 0.997 and for the United States is 1.034.

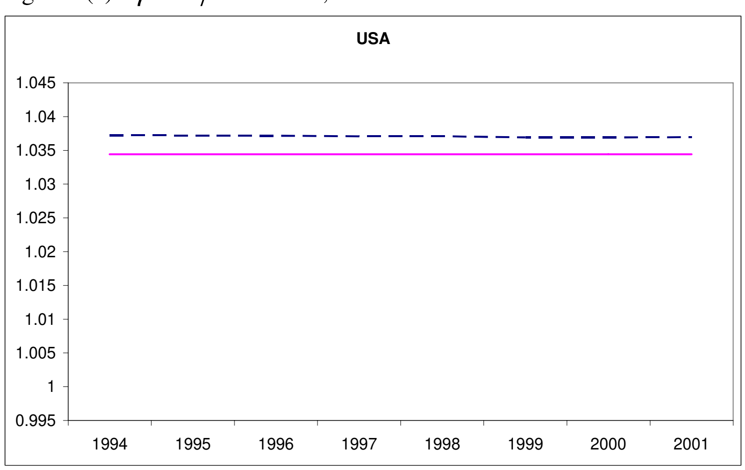
Table 3. Country-Specific Parameter Estimates

Country	Estimate	t-stat
Argentina	1.016	7.2
Australia	1.027	7.5
Austria	1.046	7.6
Belgium	1.032	7.5
Brazil	1.011	7.2
Bulgaria	0.988	7.1
Canada	1.037	7.6
Chile	1.042	7.6
China	1.080	7.6
Columbia	1.050	7.6
Czech Republic	1.034	7.5
Denmark	1.040	7.6
Egypt	0.838	4.1
Finland	1.037	7.6
France	1.050	7.7
Germany	1.045	7.6
Greece	1.057	7.7
Hong Kong	1.043	7.6
Hungary	1.033	7.5
India	0.334	0.5
Indonesia	0.908	4.2
Ireland	1.048	7.6
Israel	1.003	7.3
Italy	1.025	7.4
Japan	1.042	7.6
Korea	1.042	7.6
Malaysia	1.029	7.5
Mexico	0.997	7.1
Netherlands	1.039	7.6
New Zealand	0.984	7.2
Norway	1.040	7.6
Other Eastern Europe	1.061	6.9
Other Latin America	1.035	7.5
Other Middle East / Africa	1.009	5.8
Philippines	0.885	5.2
Poland	1.016	7.3
Portugal	1.051	7.7
Romania	0.896	4.6
Russia	0.911	6.4
Saudi Arabia / Gulf States	0.789	4.1
Singapore	1.036	7.6
Slovakia	1.015	7.4
Slovenia	1.028	7.5
South Africa	1.050	7.6
Spain	1.041	7.6
Sweden	1.045	7.6
Switzerland	1.034	7.5

Taiwan	1.039	7.5
Thailand	1.019	7.3
Turkey	1.005	7.1
United Kingdom	1.029	7.5
United States	1.034	7.5
Venezuela	0.931	6.3

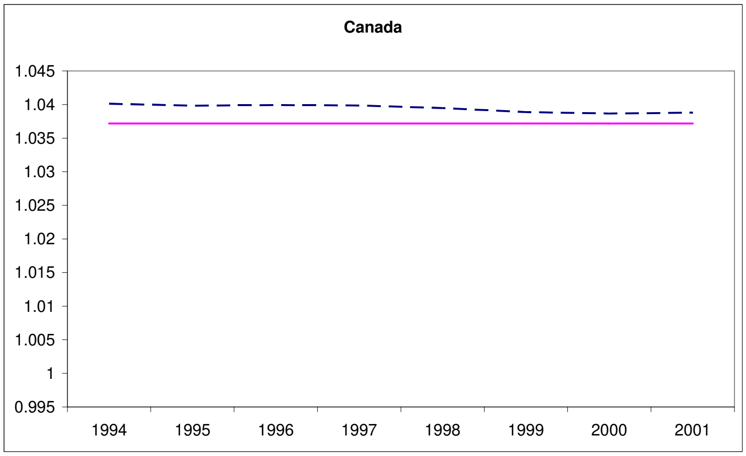
These country-specific parameter estimates are also represented as horizontal lines in Fig. 4(a) through Fig. 4(b), to aid comparison with the time-varying estimates of ϕ. Measuring e-readiness by the gap between ϕ and η, Fig. 4(a) through Fig. 4(d) illustrates a noticeable improvement in e-readiness for Brazil, a more modest improvement for Canada, virtually no change for the United States and possibly some deterioration for Mexico. However, because Canada and the United States commence the period at a much higher level of e-readiness there is less room for improvement. That is, their expenditure shares are closely aligned with their βs. Whereas for Mexico, a distinct lack of e-readiness is reflected in substantially greater functional dependence of expenditure shares on the αs.

Figure 4(a). η and ϕ Estimates, United States



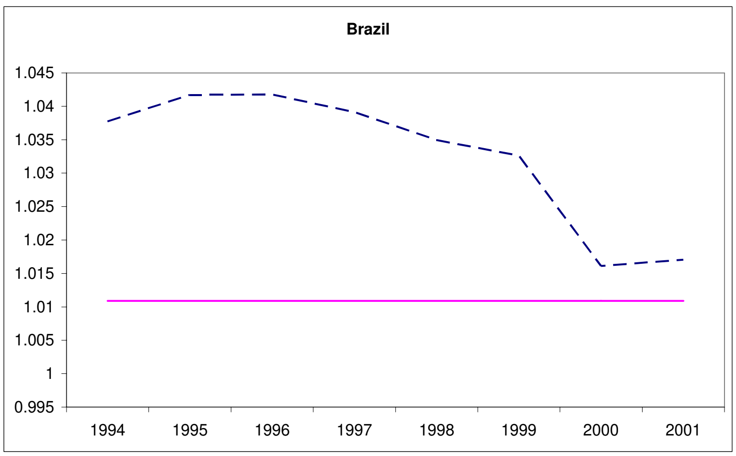
Note: η is the solid line; ϕ is the dashed line.

Figure 4(b). η and ϕ Estimates, Canada



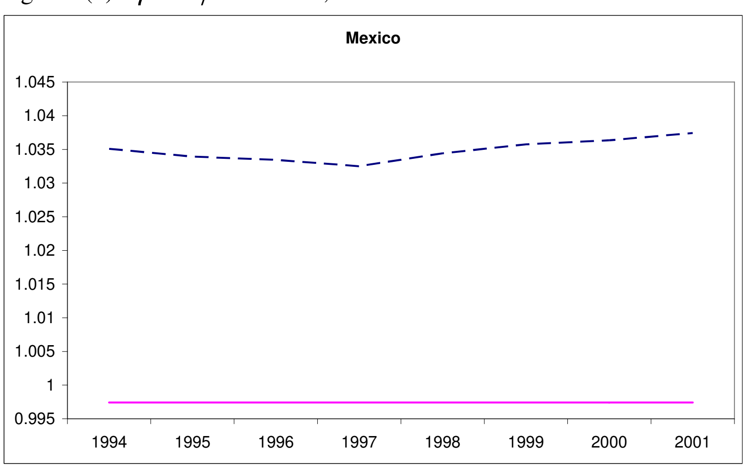
Note: η is the solid line; ϕ is the dashed line.

Figure 4(c). η and ϕ Estimates, Brazil



Note: η is the solid line; ϕ is the dashed line.

Figure 4(d). η and ϕ Estimates, Mexico



Note: η is the solid line; ϕ is the dashed line.

Table 4 provides summary fit statistics for the overall pooled data set and for Brazil, Canada, Mexico and the United States. Not surprisingly, in view of the fact that estimation was for a pooled data set of 53 countries and 8 annual observations, the fit statistics are better for the full data set than equivalent country statistics.

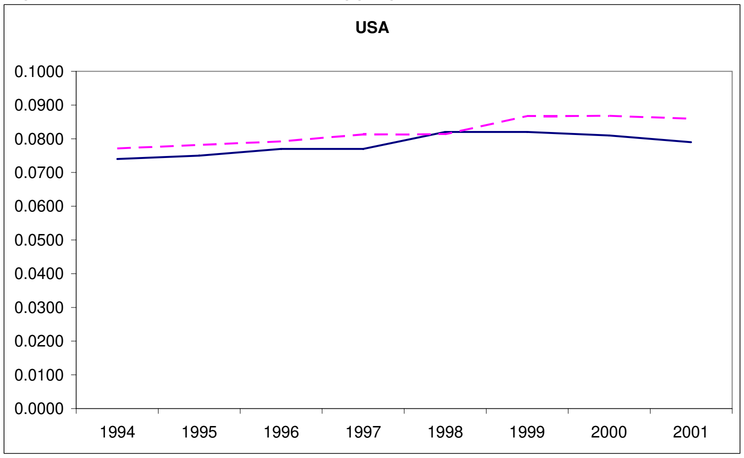
Table 4: Share Equation Fit Statistics

R^2 Statistic					
Equation	Overall	Brazil	Canada	Mexico	United States
TELE	0.90	0.68	0.86	0.74	0.61
ITInt	0.98	0.45	0.54	0.28	0.84
ITOE	0.90	0.82	0.60	0.00	0.25
ITSoft	0.96	0.80	0.96	0.28	0.96
ITHard	0.91	0.79	0.80	0.38	0.42
ITServ	0.97	0.79	0.84	0.41	0.97
Rest of GDP	0.95	0.71	0.83	0.51	0.65

Durbin-Watson Statistic					
Equation	Overall	Brazil	Canada	Mexico	United States
TELE	1.61	2.02	0.63	0.39	0.05
ITInt	1.66	1.98	2.14	1.86	1.38
ITOE	2.17	1.22	1.52	2.29	0.84
ITSoft	2.27	2.30	2.25	0.98	2.30
ITHard	2.04	1.57	0.98	2.04	0.75
ITServ	1.48	1.45	1.63	1.23	1.44
Rest of GDP	1.69	1.88	1.33	0.63	0.41

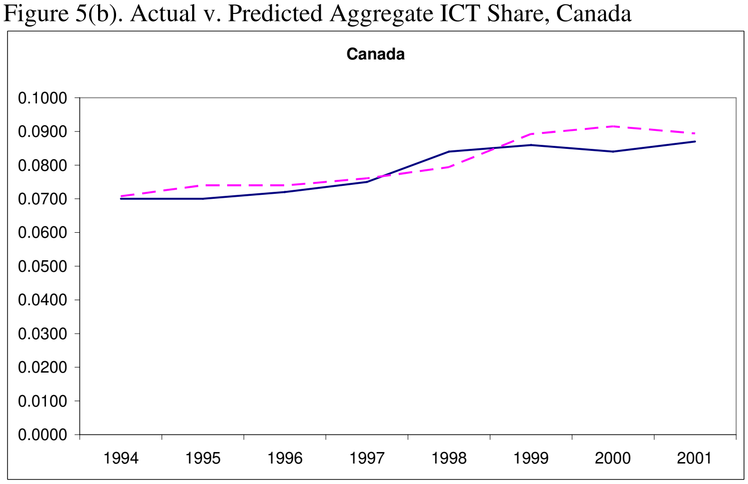
Additional model validation is provided by an historical simulation. The simulation is reported in Fig. 5(a) through Fig. 5(d) for aggregate ICT expenditure shares. The figures indicate the within-sample model simulations track reasonably well against actual shares.

Figure 5(a). Actual v. Predicted Aggregate ICT Share, USA



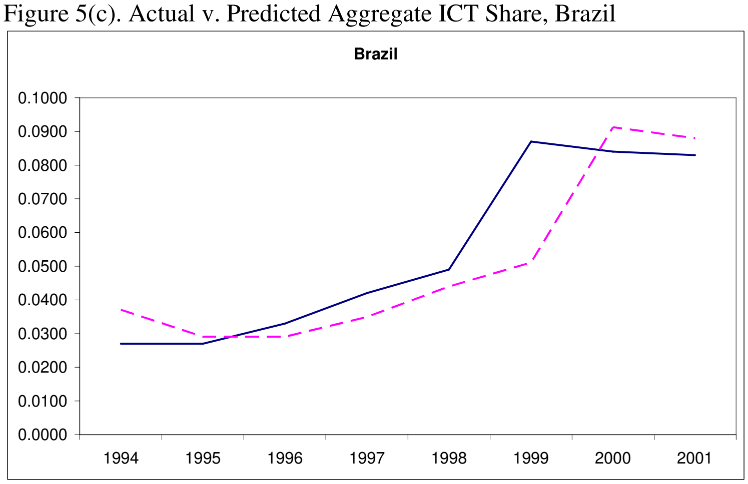
Note: Actual is the solid line; predicted is the dashed line.

Figure 5(b). Actual v. Predicted Aggregate ICT Share, Canada



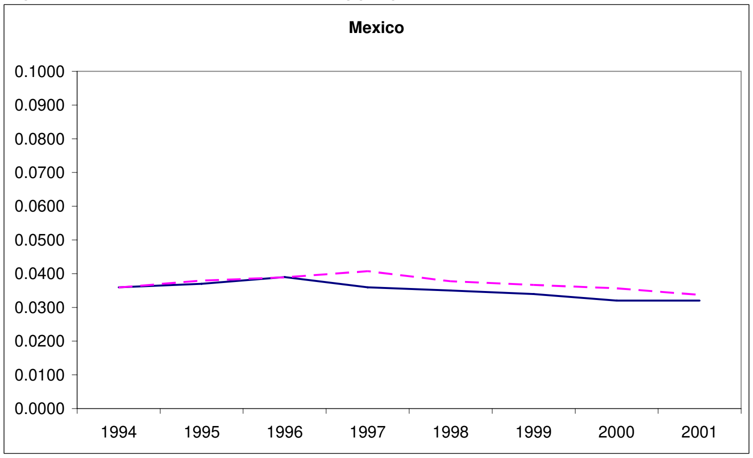
Note: Actual is the solid line; predicted is the dashed line.

Figure 5(c). Actual v. Predicted Aggregate ICT Share, Brazil



Note: Actual is the solid line; predicted is the dashed line.

Figure 5(d). Actual v. Predicted Aggregate ICT Share, Mexico



Note: Actual is the solid line; predicted is the dashed line.

5. Conclusion

This study specifies a model to provide estimates of national ICT component expenditure shares (as a proportion of GDP) when only a short time series is available for estimation. A feature of the model design is an ability to generate time-varying and country-specific parameter estimates. The estimates offer insight into Old Economy to New Economy transformation as a nation becomes more e-ready. Clearly, such information is useful as a predictive tool, viz. information from more e-ready countries can aid the conditional forecasting for less e-ready countries based on projections of their transition towards e-readiness.

The results are somewhat encouraging with some national expenditure shares accurately predicted, especially with limited data available since the inception of the New Economy. Also, the data series are not only short, but crude in that they relate to aggregated consumer and producer expenditures, and no industry-specific information is available. Importantly, given the disparate national ICT expenditure patterns (as a share of GDP) observed in these data, combined with the need to pool data for estimation, the specification allows for non-homothetic preferences. Non-homotheticity is confirmed by the results. That is, ICT, as a proportion of GDP, is likely to rise from 2% for an Old Economy to near 8 % in the long run for a New Economy. Finally, the utility function requires further generalization to ensure that no countries violate parameter restrictions implied by rationality.

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