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A Contribution to Welfare-Consistent Productivity Measurement*

Abstract

Conventionally, the trend rate of productivity growth is viewed as a key economic variable that determines the rate of potential GDP growth, how fast living standards increase, and the economy's ability to operate with low inflation and unemployment. Clearly, there must be a connection between productivity and welfare or at least productivity and potential economic welfare. Oulton argues that a more appropriate measure of welfare is Weitzman's 'Net Domestic Product'—consumption plus net investment deflated by the price index for consumption. Using Weitzman's Net Domestic Product Oulton develops a 'Total Factor Welfare' measure of economic performance. In a similar vein, Jorgenson and Landefeld, in the context of reviewing the state of the United States national economic accounts, introduce their version of a welfare-based measure of TFP, which they refer to as a 'Level of Living' index. In another parallel development, Nordhaus derived a 'Theoretically Correct (Ideal) Measure of Productivity Growth' using the tools of index number theory. The present study seeks to contribute to this research program recently established by Jorgenson, Landefeld, Nordhaus, Oulton and Weitzman. In particular, it further examines the notion of welfare-based productivity measurement within an inter-temporal optimization framework. The proposed 'Welfare-Consistent Productivity' measure is both optimization model consistent and incorporates core features attributable to the permeation of ICT as a general purpose technology in the transition from an Old Economy to a New Economy.

Keywords: Productivity, Welfare-Consistent measurement, New Economy

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1. Introduction

Conventionally, the growth rate of total factor productivity (TFP) is the rate at which the GDP frontier shifts outward through time. The corresponding trend rate of productivity growth is a key economic variable that determines the rate of potential GDP growth, how fast living standards increase, and an economy's ability to operate with low inflation and unemployment (Baily 2002). As Krugman (1990: 9) stresses, "Productivity isn't everything, but in the long run it's almost everything". From this argument it seems clear that there must be a connection between productivity and welfare or at least productivity and potential economic welfare (Oulton 2004).[1] However, the link between productivity growth and economic welfare is actually not obvious (Nordhaus 2002a: 2). Additionally, Oulton (2004: 330-1) notes that, 'from a welfare point of view only consumption matters; investment goods are desired only insofar as they can produce consumption in the future'. Accordingly, Oulton argues that a more appropriate measure of welfare is Weitzman's 'Net Domestic Product'—consumption plus net investment deflated by the price index for consumption (Weitzman 1976, 1997). Using Weitzman's Net Domestic Product Oulton develops a 'Total Factor Welfare' measure of economic performance. In a similar vein, Jorgenson and Landefeld (2005), in the context of reviewing the state of the United States (USA) national economic accounts, introduce their version of a welfare-based measure of TFP, which they refer to as a 'Level of Living' index. This index is based on a measure proposed by Weitzman (2003). In another parallel development, Nordhaus (2002a) recently derived a 'Theoretically Correct (Ideal) Measure of Productivity Growth' using the tools of index number theory. Also, Nordhaus elegantly demonstrates that this ideal welfare-theoretic measure is a chain index of productivity rates of different sectors which uses current nominal output as weights. Finally, Nordhaus separates aggregate productivity growth into a productivity effect, the effect of changing shares (Baumol effect), the effect of different productivity level (Denison effect) and fixed-weight drift term.[2]

The present study seeks to contribute to this research program recently established by Jorgenson, Landefeld, Nordhaus, Oulton and Weitzman. The analysis is conducted within an inter-temporal optimization framework. The approach is based on the belief that performance evaluation is only 'fair' when criteria are closely aligned with economic agents' objectives. That is, productivity measures typically employ output in the performance calculations. However, a representative consumer-firm rarely, if ever, explicitly maximizes output. Additionally, most macro-level analyses adopt a growth accounting framework and compute residual-based TFP via an aggregate production

[1] However, productivity and welfare are not identical. Welfare has many dimensions that may not be correlated with economic welfare, viz., welfare obtained from the consumption of goods and services measured in national accounts.

[2] Importantly, Nordhaus demonstrated that none of the measures generally used to measure productivity growth in the New Economy debate is consistent with the theoretically correct measure. Nordhaus (2002b) applies this index of productivity to measures the extent and sources of the post-1995 productivity rebound using 'well-measured' output. Of many results, Nordhaus finds that productivity growth in the New Economy sectors has made a significant contribution to economy-wide productivity growth.

function.[3] This growth accounting approach—often associated with optimal growth theory models—suggests that a more sophisticated consumer-firm model might usefully be integrated into the methodology. Accordingly, the model developed here is consistent with the notion of stochastic inter-temporal decision making in which the links between consumption and production decisions are recognized. The utility-based optimization model is then applied at a macro level within a representative agent paradigm. In particular, the model is compatible with a stochastic inter-temporal utility maximizing agent constrained by a national investment-production-consumption trade-off. By employing a time-separability assumption the agent is treated as optimizing in stages. Namely, a given potential GDP is allocated between production, and consumption of components of GDP. The decision is made by maximizing instantaneous utility subject to given potential GDP, and associated GDP component prices. The approach assumes that the representative agent purchases components of GDP to obtain utility. This treatment captures, in a stylized manner, the idea that the allocation of GDP results from a process of optimization subject to constraint.[4] Given the time-separable inter-temporal context, the value of the instantaneous inter-temporal objective is a suitable 'output' measure with which to evaluate representative agent economic performance. To assess the agent's productivity this output must be measured relative to an input. Clearly, appropriate 'input' valuation of the fundamental resources constraining the optimization is required to be measured in utility terms. Therefore, the 'Welfare-Consistent TFP' measure proposed here is the ratio of instantaneous utility to the cost of utility attainment, viz., GDP valued in utility terms.

An intention of the paper is to specify conditional decision-making in a manner that will enable parameter estimates for the instantaneous utility function of a representative consumer-firm to be obtained econometrically. The estimated share equations are considered either consumer or producer input demands (or both). An indirect utility function, defined over nominal GDP and an aggregate price deflator, is used to represent that, conditional on nominal GDP (the value of which is endogenous in the full model and determined from maximization of inter-temporal utility subject to the production-investment-consumption trade-off), expenditure shares are chosen optimally. Concentrating on the conditional instantaneous component of the model ordinality of the instantaneous utility function needs to be addressed. Being embedded within a time additive inter-temporal objective function the instantaneous function is unique only to an additive transformation. The modular design (in particular, inter-temporal separability) allows duality theory to be used to obtain conditional share equations consistent with optimization, which then provide the parameters for evaluation of model-consistent productivity. This feature is demonstrated even though price data are not available, i.e., the responsiveness of certain representative agent decisions to prices can still be inferred.

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[3] Micro-level analyses also employ growth accounting methods. See Brynjofsson and Hitt (2003) for a recent example.

[4] At the inter-temporal level, decisions about allocation of GDP are made so as to maximize the present value of the expected utility stream. Effectively, at this stage GDP is made endogenous as a function of underlying capital.

To operationalize the concepts Welfare-Consistent Productivity measurement is examined within the context of the New Economy debate. This focus is chosen (in particular for the G7 Member Countries—Canada, France, Germany, Italy, Japan, the United Kingdom and the USA) as the productivity rebound of the mid-1990s is a much debated topic (and much recent agreement), thus providing a basis from which to sanity check study findings. The New Economy debate recognizes an acceleration of GDP growth occurred in many OECD Member Countries from the mid-1990s, but particularly the USA (van Ark 2002). Between 1995 and 2001, output per hour in the business sector advanced at 2.4% average annual rate or 0.9 percentage points faster than for 1990-1995 (Conference Board 2002). This development is taken by many as *prima facie* evidence of a New Economy based on information and communications technology (ICT). For instance, Jorgenson and Stiroh (2000) and Jorgenson (2001) stress that this acceleration in growth is mainly attributable to the performance of the ICT-producing sector. Further, Onliner and Sichel (2000) and Baily and Lawrence (2001) demonstrate an increase in the productive ICT-good use elsewhere in the economy. However, Gordon (2000) argues that the entire acceleration in productivity growth post-1995, after adjusting for cyclical effects, is due to faster TFP growth in the IT sector. This improved performance is argued to have added directly to productivity growth and the resulting decline in the price of IT capital induced rapid capital accumulation that added to labor in the rest of the economy (Baily 2002).

The paper is structured as follows. In Section 2 information on the data set on ICT expenditure is provided. Section 3 specifies the share equation model. Econometric estimates are reported in Section 4. Section 5 discusses computed welfare-consistent statistics. Section 6 conducts a sanity check of Welfare-Consistent TFP against best practice conventionally estimated TFP values. A final section suggests some modeling extensions.

2. Data and Concepts

Table 1 lists G7 Member Country annual ICT expenditure for 2000–2003. The complete data set lists these expenditures for 47 countries.[5] In particular, ICT expenditure is split into: communications (COM); and IT software (SOFT), hardware (HARD) and services (SERV) components. Inspection of the columns of Table 2 clearly reveals that the implied expenditure shares are non-homothetic. The COM expenditure share is highest for the low-income region of South Africa. However, the pattern is not monotonic with the next largest share attributed to the G7 and Eastern Europe, respectively. The software expenditure share (SOFT/GDP) is lowest for the low-income regions of Developing Asia and Latin America. Further, the G7 SOFT/GDP values are an order of magnitude of 3 to 7 times larger than for the low-income region values. A different pattern holds for the IT

[5] An initial data set of 70 countries is developed from WITSA *Digital Planet 2004* data. Supplementing these data with national GDP deflators from the International Monetary Fund's *International Financial Statistics* required a reduction in country coverage. Further, several African, Latin American, Eastern European, Asia-Pacific and Middle Eastern countries are removed due to the poor quality of these data. The net impact of the adjustments is a group of 47 countries available for estimation. An extended version of Table 1 for the 47 country set actually employed in estimation is provided in Appendix Table 1.

hardware expenditure share (HARD/GDP). However, the scale of high-income to low-income region expenditure share is approximately of order 2. Finally, the SERV/GDP ratio clearly follows that for HARD/GDP, however, the relative size for the high-income to low-income expenditure ratio is between 3 and 6.

Table 1. G7 Member Selected National Statistics, 2000–2003

Year	COM	SOFT	HARD	SERV	GDP	POP	PGDP	RGDPCAP	RCNORM
Canada									
2000	20717	3855	9501	10310	724095				
2001	18552	4185	9009	11027	715015	31.0	1.000	22.850	49.891
2002	19906	4297	9550	11143	735479	31.3	1.010	23.027	50.277
2003	22675	4833	10006	12290	866946	31.6	1.044	26.018	56.808
France									
2000	32340	8707	16668	27149	1309742				
2001	31353	9203	15575	28267	1320379	59.2	1.000	21.903	47.823
2002	35373	10097	15236	30520	1442234	59.5	1.022	23.300	50.873
2003	43184	11183	15664	33147	1759220	59.8	1.038	27.855	60.819
Germany									
2000	45488	12321	30925	26356	1869430				
2001	43632	13127	27889	27663	1857357	82.3	1.000	22.274	48.633
2002	48279	14527	26888	30129	1994713	82.5	1.015	23.526	51.367
2003	59037	16092	28096	32728	2406940	82.5	1.023	28.164	61.493
Italy									
2000	23627	4604	10521	12379	1075516				
2001	22610	4748	10629	12576	1090031	57.9	1.000	18.343	40.050
2002	24894	5147	9674	13417	1189410	58.0	1.030	19.388	42.332
2003	31015	5605	9881	14329	1469870	58.1	1.061	23.235	50.731
Japan									
2000	227687	13846	91258	68180	4748464				
2001	182163	13436	64500	65178	4163154	127.1	1.000	33.250	72.598
2002	170895	13100	51531	62545	3984303	127.4	0.989	32.097	70.081
2003	185315	14289	51043	66900	4305128	127.7	0.964	35.530	77.576
United Kingdom									
2000	50655	11780	23872	30483	1440310				
2001	44980	12316	22535	31399	1432833	59.5	1.000	23.579	51.483
2002	49450	13472	21442	33804	1568744	59.6	1.034	24.929	54.430
2003	58155	15194	21130	37391	1799988	59.7	1.067	27.664	60.402
USA									
2000	439963	94063	163893	234247	9816975				
2001	414709	98103	123032	240716	10100775	285.7	1.000	34.524	75.380
2002	446636	97204	113537	234747	10480825	288.6	1.017	34.857	76.107
2003	481941	107080	119725	253632	10987875	291.4	1.038	35.465	77.434

Table 2. Average ICT Expenditure by Region, 2000–2003

Region	COM/GDP (%)	SOFT/GDP (%)	HARD/GDP (%)	SERV/GDP (%)
G7	3.8	0.7	1.3	2.0
Industrialized Non-G7	3.3	0.5	1.1	1.1
Eastern Europe	3.4	0.4	1.0	0.7
Latin America	3.3	0.2	0.9	0.6
South Africa	5.3	0.6	1.3	1.1
Developing Asia	2.9	0.1	0.7	0.3

Note. Regions listed by descending GDP per capita

Table 1 also lists G7 Member nation GDP (current US$ million), population (million persons, POP), the GDP deflator (indexed at unity in 2001, PGDP), real GDP per capita (RGDPCAP) and normalized real per capita GDP (RCNORM) data. RCNORM is indexed to unity for India in 2001.[6] The proposed Welfare-Consistent TFP measure applies a monotonic transformation to the RCNORM index where the concavity of the transformation reflects diminishing marginal utility. The logarithmic utility function $U = \ln(c/P)$, where c is nominal GDP and P is the GDP deflator, is commonly employed in macroeconomic models, especially growth models. P is interpreted as a price index and $\ln(c/P)$ considered an indirect utility function. The proposed welfare-based TFP measure treats utility as output with input measured by the cost of obtaining this utility or GDP evaluated in utility terms, i.e., $U/(c\partial U/\partial c)$.[7] The utility-based approach to TFP measurement highlights the importance of welfare—as distinct from output—as the objective.

3. The Model

To operationalize the optimization program requires the specification of an instantaneous indirect utility function. The utility function must be flexible enough to allow for the non-homothetic expenditure shares evident in these data. The expenditure system employed is a generalization of the Almost Ideal Demand (AID) system (Deaton and Muellbauer 1980). The AID system allows for non-homotheticity by expressing indirect utility as a function of money (nominal GDP) and price indexes— $A(p)$ and $B(p)$. Because GDP expenditure share price data are not available a variant of the AID specification that uses Cobb-Douglas indexes is employed:[8]

[6] From Table 1, the Canadian RCNORM value in 2001 is 49.891. This value means that the 2001 Canadian per capita GDP is approximately 50 times that of India in 2001.

[7] Note that when utility has the logarithmic form $c\partial U/\partial c = 1$ and $TFP = U$.

[8] Ideally quality-adjusted prices and quantities for all components of GDP should be used in estimation. However, these data are not available. For example, Jorgenson (2005) notes, "Unfortunately, evidence on the price of software is seriously incomplete, so the official price indexes are seriously misleading". Further, while Jorgenson employs the 'internationally harmonized' IT price series constructed by Schreyer (2000) to make international comparisons, these series are not available for the full set of countries or expenditure shares considered.

$$s_i = \alpha_i + \beta_i \{\ln c - \sum_k \alpha_k \ln p_k\}, \quad i = 1,....,5. \tag{1}$$

Equation (1) is obtained from Roy's identity applied to the indirect utility function:

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

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

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

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

Econometric estimation of (1) provides values for the price index parameters α_k and β_k. Importantly, the estimates are obtained when GDP component prices are not available by using an aggregate deflator as a proxy for the $\sum_k \alpha_k \ln p_k$ terms. The corresponding approximate system is:

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

where c / P is real GDP. The α_i are interpreted as price index weights used to calculate the GDP deflator when GDP is relatively low (an Old Economy), while the β_i represent corrections as the economy grows and innovates to a New Economy.[9]

An issue that should be addressed when specifying the AID system for econometric estimation is that extrapolating the shares implied by (1) leads to the predicted shares falling outside the unit interval when real GDP growth is 'too large'. The problem is resolved by modifying the AID system in a manner that results in a fractional share system in which the predicted shares are constrained to lie within the unit interval, regardless of the magnitude of real GDP (see Cooper and McLaren 1992). The modified AID system (MAIDS) employed for estimation has the form:[10]

$$s_i = \frac{\alpha_i + \left[(1-\phi)\beta_i + (\phi - \eta)\alpha_i\right]\ln(c / A(p))}{1 + (1-\eta)\ln(c / A(p))} \tag{6}$$

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[9] α_i is considered the Old Economy price index weight as $c / P = RCNORM = 1$ for (the reference economy) India in 2001 (at which point $\ln 1 = 0$ so that $s_i = \alpha_i$). $\beta_i > 0$ means the marginal component expenditure share rises with $RCNORM$.

[10] A strength of the MAIDS approach is that an aggregate price index can be used to obtain consistent parameter estimates in the absence of expenditure component quality-adjusted price data.

which is derived from the indirect utility function:

$$U(c,p)=\left(\frac{c}{B(p)}\right)^{1-\phi}\left(\frac{c}{A(p)}\right)^{\phi-\eta}\ln(c/A(p)),\quad \eta\le\phi\le 1 \tag{7}$$

where price indexes $A(p)$ and $B(p)$ are as defined by (3) and (4), however, $\sum \beta_i = 1$.

Next, the functional form for the Old Economy price index—$A(p)$ in $\ln\{c/A(p)\}$—is generalized to allow the index to more accurately be treated as the current GDP deflator. In particular, the index is modified to allow for path dependence with share adjustment dependent on previous share values. That is, the choices of optimal share values are influenced by recent expenditures with:

$$U(c,p)=\left(\frac{c}{B(p)}\right)^{1-\phi}\left(\frac{c}{A(p)}\right)^{\phi-\eta}\ln\{c/A^*(p,c,s_{-1})\},\quad \eta\le\phi\le 1 \tag{8}$$

with

$$\ln A^*(p,c,s_{-1})=\ln A(p)+\sum_k \gamma_k\left[s_{k,-1}-s_{\underline{k}}\right]\ln(p_k/c) \tag{9}$$

where $s_{k,-1}$ are lagged category k expenditure shares, $s_{\underline{k}}$ is the share in India in 2000 (lag value in 2001) and s_{-1} is a one-period lag share vector.[11] In (8), $A^*(p,c,s_{-1})$ is interpreted as the GDP deflator.[12] The implied optimal share equations from (9) are:

$$s_i=\frac{\alpha_i+\gamma_i\left[s_{i,-1}-s_{\underline{i}}\right]+\left[(1-\phi)\beta_i+(\phi-\eta)\alpha_i\right]\ln\{c/A^*(p,c,s_{-1})\}}{1+\sum_k\gamma_k\left[s_{k,-1}-s_{\underline{k}}\right]+(1-\eta)\ln\{c/A^*(p,c,s_{-1})\}}. \tag{10}$$

In (10), ϕ and η influence the extent to which the expenditure shares depend on Old Economy (α_i) and New Economy (β_i) parameters. For instance, with $\phi=1$ the parameter β_i has no impact on expenditure share values. However, when $\phi<1$ then β_i influences these values. Irrespective of how much ICT permeates an economy it seems reasonable to treat ϕ as varying in a manner that has β_i increasingly influencing expenditure shares through time (as the New Economy becomes more pervasive).[13] Accordingly, in (8) the greater is the magnitude of the exponent $1-\phi$ relative to $\phi-\eta$ the more weight is given to the New Economy parameters in $B(p)$. Convergence to a

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[11] For the reference company (India in 2001) $\ln A^*(p)=0$.

[12] In (9), $A(p)$ is HD1 in prices. Inclusion of the $\ln(p_k/c)$ term ensures the utility function (8) is HD0 in money and prices.

[13] Conversely, with $\phi=\eta$ the Old Economy parameter only has an impact via α_i in the numerator.

New Economy occurs as $\phi \to \eta$. Time and country varying specifications assumed for ϕ and η are:

$$\eta_{j,t} = \frac{(ICT/GDP)_{j,t-1}}{(ICT/GDP)_{j,2000}} \eta_{j,2001} \text{ , } t = 2001,...,2003 \tag{11}$$

and

$$\phi_{j,t} = 1 + (\eta_{j,t} - 1) \frac{(ICT/GDP)_{j,t-1} - (ICT/GDP)^0_{j,t}}{1 - (ICT/GDP)^0_{j,t}} \tag{12}$$

where $(ICT/GDP)^0_{j,t}$ is a time and country varying measure of the ICT shares that is solely based on Old Economy (subsistence) technology (e.g., basic switched-circuit telephony and non-networked computing). Equation (12) moves ϕ toward η the more the immediate past ICT expenditure share rises above the current subsistence requirement.[14] In (11), η is specified as country specific and rises as the preceding ICT expenditure share moves further above the year 2000 base share.

The paths of ϕ and η also determine the path of TFP. However, measuring TFP by $U/(c\partial U/\partial c)$ is problematic as any monotonic transformation of the utility function (8) yields the same share system (10). To address this issue the atemporal allocation problem is modeled as a time-separable component of a broader inter-temporal optimization. A time-additive structure (in which the agent's objective is to maximize the expected present value of a future utility stream) only requires that the instantaneous indirect utility function be identified to within an additive transformation. To interpret the optimal value of the instantaneous objective function and enable national and intertemporal comparison, the following utility transformation is specified,

$$\tilde{U}_j = \mu_{0,j} + \mu_{1,j} U(c, p) \text{ .} \tag{13}$$

[14] Naturally the subsistence share is not constant but, starting from the base ICT/GDP of India in 2000, attenuates through time with increased real per capita GDP according to the rule:

$$(ICT/GDP)^0_{j,t} = (ICT/GDP)_{\text{INDIA},2000} 2(1 - \frac{RCNORM_{j,t}}{1 + RCNORM_{j,t}}) \text{ .}$$

At one extreme (India in 2001) $RCNORM = 1$ so that the base subsistence ICT expenditure share is then,

$$(ICT/GDP)_{\text{INDIA},2000} 2(1 - \frac{1}{1+1}) = (ICT/GDP)_{\text{INDIA},2000} \text{ .}$$

At the other extreme, as $RCNORM \to \infty$ then $(ICT/GDP)^0_{j,t} \to 0$.

Equation (13) is an affine transformation of the underlying indirect utility function (8). As the parameters $\mu_{0,j}$ and $\mu_{1,j}$ are not econometrically estimable, $\tilde{U}_j$ is normalized by setting reference year utility (2001) equal to national real GDP per capita (i.e., $\tilde{U}_{j,2001} = RCNORM_{j,2001}$) and $TFP_{j,2001} = 1 + U(CNORM_{j,2001}, p_{j,2001})/(CNORM_{j,2001}\theta_{j,2001})$ for all j where $\theta \equiv \partial U(c,p)/\partial c$. These conditions are met by the specifications:

$$\mu_{0,j} = RCNORM_{j,2001} /(1+U(CNORM_{j,2001}, p_{j,2001})/(CNORM_{j,2001}\theta_{j,2001})) \tag{14}$$

and

$$\mu_{1,j} = \mu_{0,j} /(CNORM_{j,2001}\theta_{j,2001}) .$$

The restrictions force the utility measure (13) to equal normalized real per capita GDP for all countries in year 2001, normalize TFP to unity for (reference country) India in year 2001 and construct a relativity in TFP cross country in the base year compatibly with the relativities in $U/c\theta$. The corresponding Welfare-Consistent TFP measure is:

$$TFP_j = \frac{\tilde{U}_j}{c\partial\tilde{U}_j/\partial c} = \frac{\mu_{0,j}}{\mu_{1,j}\, c\,\theta} + \frac{U(c,p)}{c\,\theta} . \tag{15}$$

The Welfare-Consistent TFP measure corresponding to (8) is,

$$TFP = \frac{(\mu_0/\mu_1)(B/c)^{1-\phi}(A/c)^{\phi-\eta} + \ln\{c/A^*(p,c,s_{-1})\}}{1+\sum_k \gamma_k \left[s_{k,-1} - s_{\underline{k}} \right] + (1-\eta)\ln\{c/A^*(p,c,s_{-1})\}} . \tag{16}$$

4. Estimation and Results

With one share redundant due to adding up, the non-ICT share equation, is dropped for estimation and the four ICT share equations are estimated as a joint nonlinear system. The non-homothetic specification plus one country-specific parameter ($\eta_{j,2001}$) justifies pooling national data. An observation (year 2000) is dropped to allow construction of lagged share variables with estimation based on pooled national 2001–2003 series. Table 3 provides summary fit statistics for the pooled data set. The reported Durbin-Watson statistics indicate an absence of first-order autocorrelation among the residuals. Sample R^2 are highest for the COM (0.95), SOFT (0.97) and SERV (0.97) share equations. R^2 for the HARD equation is lower at 0.87.

Table 3. Equation Fit Statistics

Statistic	COM	SOFT	HARD	SERV
Durbin-Watson	2.21	1.99	1.69	1.96
R^2	0.95	0.97	0.87	0.97
Log likelihood	3138			
Observations	$138 \times 4 = 552$			

Table 4 contains parameter estimates for α_{SOFT}, α_{HARD}, α_{SERV} and $\alpha_{\text{Non-ICT}}$ from share system (10). The parameters are interpreted as predicted shares for an Old Economy, viz., India in 2001 (the reference country). An estimate for α_{COM} is determined by adding-up. All coefficients are individually significant at the 1% level. The magnitude of the estimated parameters are plausible with the estimated value of α_{COM} largest at 2.63% of GDP, HARD (0.48%) is next largest followed by SERV (0.24%) and SOFT (0.06%). The β_i estimates are limiting shares associated with technology-preferences when real GDP becomes large and new technology permeates the economy (when ϕ falls to η). The β_{COM} value is determined by adding-up. All estimated coefficients, except β_{SERV}, are individually significant at the 1% level. Further, the estimated coefficient values are intuitively plausible as $\beta_{\text{COM}}(11.56\%) > \alpha_{\text{COM}}(2.63\%)$, $\beta_{\text{SOFT}}(1.71\%) > \alpha_{\text{SOFT}}(0.06\%)$, $\beta_{\text{HARD}}(3.84\%) > \alpha_{\text{HARD}}(0.48\%)$ and $\beta_{\text{SERV}}(0.96\%) > \alpha_{\text{SERV}}(0.24\%)$. Comparison of the estimates for $\alpha_{\text{Non-ICT}}$ and $\beta_{\text{Non-ICT}}$ indicate that the aggregate ICT expenditure share rises from approximately 3.5% of GDP for a low-income Old Economy (India in 2001) to nearly 18% of GDP ultimately for a high-income New Economy.[15] The γ_i estimates represent a persistence of past expenditure effect. ICT expenditure persistence is clearly apparent with $\gamma_{\text{COM}}(1.6991)$, $\gamma_{\text{SOFT}}(1.8712)$, $\gamma_{\text{HARD}}(1.5370)$ and $\gamma_{\text{SERV}}(1.8677)$ estimates significant at the 1% level. Finally, hypothesis tests reported in Table 5 show that the strongest lagged share effects are for SOFT and SERV, followed by COM and then HARD.

The $\eta_{j,2001}$ parameter estimates reported in Table 6 represent otherwise unmeasured differences in technology and domestic conditions. Domestic conditions may reflect the state of national competition policy and sector-specific regulation. The estimated parameters are individually significant at the 1% level. Several tests are conducted on the $\eta_{j,2001}$ parameters. In particular, Table 7 reports several hypothesis tests that consider whether the initial conditions faced by G7 Member Countries are identical. This notion is clearly rejected ($\chi^2_{calc} = 34.90 > \chi^2_{crit} = 12.60$). Another test rejects that the United Kingdom should be grouped with USA and Japan ($\chi^2_{calc} = 14.35 > \chi^2_{crit} = 11.07$). A final test of whether the G7 can be reasonably split into three groups: USA–Japan, the United

[15] This interpretation is based on extrapolation using the estimated curvature of the Engel curves.

Kingdom and the Rest (Canada, France, Germany and Italy), however, cannot be rejected ($\chi^2_{calc} = 1.16 < \chi^2_{crit} = 9.40$) based on their initial conditions.

Table 4. Share Equation MAIDS Parameter Estimates

Coefficient	Estimate	Std. error	t-statistic
α_{COM}	0.0263[a]		n.a.
α_{SOFT}	0.0006	0.0001	5.20
α_{HARD}	0.0048	0.0003	17.44
α_{SERV}	0.0024	0.0002	11.49
$\alpha_{\text{Non-ICT}}$	0.9659	0.0010	–34.10[b]
β_{COM}	0.1156[a]		n.a.
β_{SOFT}	0.0171	0.0051	3.39
β_{HARD}	0.0384	0.0136	2.82
β_{SERV}	0.0096	0.0093	1.03
$\beta_{\text{Non-ICT}}$	0.8193	0.0533	–3.39[b]
γ_{COM}	1.6991	0.0978	17.38
γ_{SOFT}	1.8712	0.1012	18.49
γ_{HARD}	1.5370	0.0766	20.06
γ_{SERV}	1.8677	0.1008	18.52
$\gamma_{\text{Non-ICT}}$	0.4613	1.0981	0.42

Note. [a] α_{COM} and β_{COM} is calculated residually by adding-up. [b] The null hypotheses are $\alpha_{\text{Non-ICT}} = 1$ and $\beta_{\text{Non-ICT}} = 1$, respectively.

Table 5. G7 Past Expenditure Persistence Hypothesis Tests

Null hypothesis	Calculated statistic	Critical χ^2 value	Conclusion
$\gamma_{\text{Non-ICT}} = 0$	0.16	3.84	Not Reject H_0
$\gamma_{\text{COM}} = \gamma_{\text{SOFT}} = \gamma_{\text{HARD}} = \gamma_{\text{SERV}}$	10.17	7.81	Reject H_0
$\gamma_{\text{SOFT}} = \gamma_{\text{SERV}}$	0.03	3.84	Not Reject H_0
$\gamma_{\text{Non-ICT}} = 0$ and $\gamma_{\text{SOFT}} = \gamma_{\text{SERV}}$	0.20	5.99	Not Reject H_0

Note. The alternative hypothesis is that the γ estimates are as reported in Table 4

Table 6. Country-Specific Initial Condition Parameter Estimates

Region	Coefficient	Estimate	Std. error	t-statistic
G7	η_{CANADA}	0.7908	0.0333	23.74
	η_{FRANCE}	0.7954	0.0305	26.09
	η_{GERMANY}	0.7994	0.0333	24.04
	η_{ITALY}	0.7857	0.0357	21.10
	η_{JAPAN}	0.8926	0.0279	31.97
	$\eta_{\text{UNITED KINGDOM}}$	0.8336	0.0317	26.33
	η_{USA}	0.8746	0.0301	29.04
Developing Asia	η_{INDIA}	0.5000[a]		n.a.
	η_{MALAYSIA}	0.6041	0.0706	8.56
	η_{THAILAND}	0.6933	0.0820	8.46
Non-G7	$\eta_{\text{AUSTRALIA}}$	0.7510	0.0396	18.96
	η_{AUSTRIA}	0.7844	0.0360	21.80
	η_{BELGIUM}	0.7828	0.0350	22.37
	η_{DENMARK}	0.8045	0.0301	26.73
	η_{FINLAND}	0.7855	0.0352	22.33
	η_{GREECE}	0.7460	0.0999	7.47
	$\eta_{\text{HONG KONG}}$	0.8186	0.0361	22.65
	η_{IRELAND}	0.7539	0.0615	12.25
	η_{ISRAEL}	0.7989	0.0394	20.28
	η_{KUWAIT}	0.7432	0.0351	21.14
	$\eta_{\text{NETHERLANDS}}$	0.7752	0.0309	25.13
	$\eta_{\text{NEW ZEALAND}}$	0.7717	0.0461	16.73
	η_{NORWAY}	0.8411	0.0276	30.48
	η_{PORTUGAL}	0.7366	0.0365	20.17
	$\eta_{\text{SAUDI ARABIA}}$	0.7412	0.0478	15.49
	$\eta_{\text{SINGAPORE}}$	0.8267	0.0404	20.47
	$\eta_{\text{SOUTH KOREA}}$	0.8166	0.0462	17.69
	η_{SPAIN}	0.7396	0.0533	13.87
	η_{SWEDEN}	0.7570	0.0296	25.61
	$\eta_{\text{SWITZERLAND}}$	0.8101	0.0325	24.96
Latin America	η_{BRAZIL}	0.4625	0.0897	5.16
	η_{CHILE}	0.6766	0.0705	9.59
	$\eta_{\text{LATIN AMERICA}}$ [b]	0.5749	0.0717	8.01
	η_{MEXICO}	0.7030	0.1088	6.46
	η_{PERU}	0.5174	0.1436	3.60
	η_{URUGUAY}	0.4596	0.1023	4.50
	$\eta_{\text{VENEZUELA}}$	0.5313	0.0965	5.51
Eastern Europe	$\eta_{\text{CZECH REPUBLIC}}$	0.5867	0.0739	7.94
	η_{HUNGARY}	0.5946	0.0751	7.92
	η_{POLAND}	0.6553	0.1080	6.07
	$\eta_{\text{SLOVAKI REPUBLIC}}$	0.5038	0.0858	5.87
Sub-Saharan Africa	$\eta_{\text{SOUTH AFRICA}}$	0.4207	0.0775	5.43

Note. [a] $\eta_{\text{INDIA}} = 0.5$ is set to ensure U is effectively globally regular, viz., $\partial^2 U / \partial c^2 < 0$. [b] Latin America group is comprised of Columbia, Costa Rica, Ecuador, Honduras and Panama.

Table 7. G7 Initial Condition Hypothesis Tests

Hypothesis	Calculated statistic	Critical χ^2	Conclusion
Common η	34.90	12.60	Reject H_0
Separate USA–Japan–United Kingdom / Rest η	14.35	11.07	Reject H_0
Separate USA–Japan / United Kingdom / Rest η	1.16	9.40	Not Reject H_0

Note. Restrictions tested against H_1: G7 η estimates are as reported in Table 6

Finally, Table 8 lists annual G7 Member Country utility, first-derivative and second-derivate function values for the sampled period. To further ensure that the Welfare-Consistent TFP estimates are calculated from a sound empirical base the annual estimated values for ϕ and η are also provided. All the estimated utility, first-derivative and second-derivative function values satisfy the properties of differentiable utility functions. Namely, for all Member Countries and sample years, utility function values are positive, marginal utility values are positive while second-derivatives are negative (exhibit diminishing marginal utility). Estimated utility and time varying parameter values for the non-G7 sampled countries are also well behaved.[16] Further inspection of Table 8 also reveals that the condition $\phi > \eta$ holds for all G7 Member Country parameter estimates. Satisfying this condition ensures that the estimated expenditure allocation model is effectively globally regular (Cooper and McLaren, 1996). Effective global regularity also holds for all or the non-G7 sampled countries.

[16] Appendix Table 2 provides utility and time varying parameter estimates for non-G7 sample countries.

Table 8. G7 Member Country Utility and Time Varying Parameter Estimates

	Utility	$\partial U / \partial c$	$\partial^2 U / \partial c^2$	ϕ	η
Canada					
2001	49.891	0.329	–0.005	0.987	0.791
2002	52.637	0.363	–0.005	0.987	0.772
2003	52.450	0.294	–0.003	0.987	0.788
France					
2001	47.823	0.326	–0.005	0.987	0.795
2002	50.202	0.326	–0.004	0.987	0.785
2003	54.507	0.300	–0.003	0.986	0.776
Germany					
2001	48.633	0.325	–0.005	0.988	0.799
2002	51.431	0.336	–0.004	0.987	0.785
2003	55.397	0.305	–0.003	0.987	0.780
Italy					
2001	40.050	0.331	–0.006	0.990	0.786
2002	42.823	0.345	–0.005	0.990	0.767
2003	49.419	0.352	–0.004	0.989	0.738
Japan					
2001	72.598	0.275	–0.003	0.991	0.893
2002	89.303	0.449	–0.005	0.987	0.826
2003	104.359	0.540	–0.005	0.985	0.791
United Kingdom					
2001	51.483	0.307	–0.004	0.987	0.834
2002	57.933	0.354	–0.004	0.985	0.798
2003	64.480	0.370	–0.004	0.983	0.774
USA					
2001	75.380	0.275	–0.003	0.988	0.875
2002	96.787	0.444	–0.004	0.983	0.799
2003	102.645	0.475	–0.004	0.982	0.784

5. A Synthesis of Welfare-Consistent TFP Index Estimates

Table 9 lists annual G7 Member Country Welfare-Consistent TFP estimates for the period 2001–2003. Welfare-Consistent TFP is measured on the utility scale by the rule $TFP = U / \theta c$ where $\theta \equiv \partial U(c, p) / \partial c$. In Table 9 Member Countries are listed within the groups suggested by hypothesis tests on initial condition parameters ($\eta_{j,2001}$). The initial year (2001) has TFP values monotonically declining for Group 1 through Group 3. This pattern is not maintained for 2002 and 2003. Indeed, for 2002 (with Japan, Canada and

Italy excluded) an inverse relationship emerges. This latter pattern (by excluding Italy) is approximately maintained in 2003.

Table 9. Welfare-Consistent TFP Estimates, 2001–2003

Group	G7 Member Country	2001	2002	2003
1	Japan	3.818	3.011	2.714
1	USA	3.670	2.839	2.713
2	United Kingdom	3.299	2.938	2.736
3	Germany	3.143	2.999	2.949
3	France	3.113	3.005	2.925
3	Canada	3.112	2.925	3.076
3	Italy	3.042	2.864	2.623

Note. Countries listed in descending order by η value

To better examine these rank order changes, Table 10 presents Member Country Welfare-Consistent TFP annual changes for 2002/2001 and 2003/2002. With Member Countries listed by initial condition parameter values it is apparent for 2002/2001 that TFP decline is greater for Group 1 than for Group 2 and greater for Group 2 than Group 3. For 2003/2002, the pattern continues to hold with the exception of an ameliorated decline for the USA, while a substantial decline is reported for Italy in Group 3. The obvious aberration is Canada whose welfare-consistent value rose in 2003/2002. Abstracting from the noted exceptions, these findings may be suggestive of the extent to which the concavity of the utility function reduces the index for wealthier countries. Concavity forces per capita GDP to be discounted more heavily in wealthier countries in measuring productivity.

Table 10. Welfare-Consistent TFP Annual Change, 2001 and 2003

Group	G7 Member Country	$T\dot{F}P_{2002/2001}$ (%)	$T\dot{F}P_{2003/2002}$ (%)
1	Japan	–23.7	–10.4
1	USA	–25.7	–4.6
2	United Kingdom	–11.6	–7.1
3	Germany	–4.7	–1.7
3	France	–3.5	–2.7
3	Canada	–6.2	5.0
3	Italy	–6.1	–8.8

Note. Countries listed in descending order by η value. $T\dot{F}P = \dot{U} - \dot{c} - \dot{\theta}$. $\dot{X} = \ln X_t - \ln X_{t-1}$ where $\dot{X} = \dot{U}, \dot{c}, \dot{\theta}$. $\theta \equiv \partial U(c, p)/\partial c$

This pattern is also apparent from the visual inspection of Figure 1 and Figure 2.

Fig. 1. National Welfare-Consistent TFP Change by Average Consumption, 2000–2002

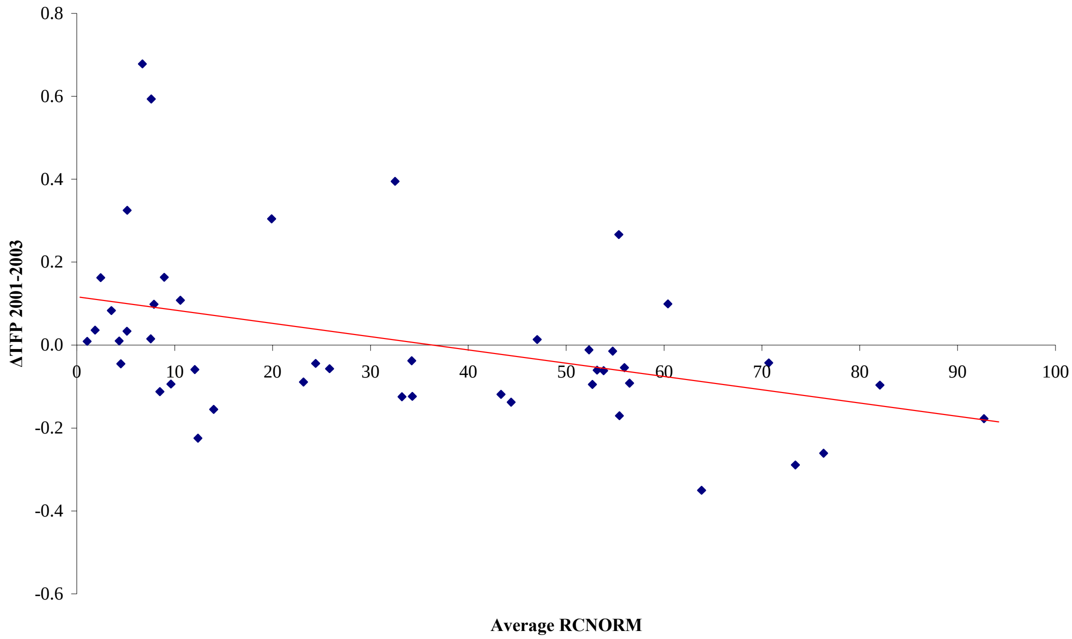
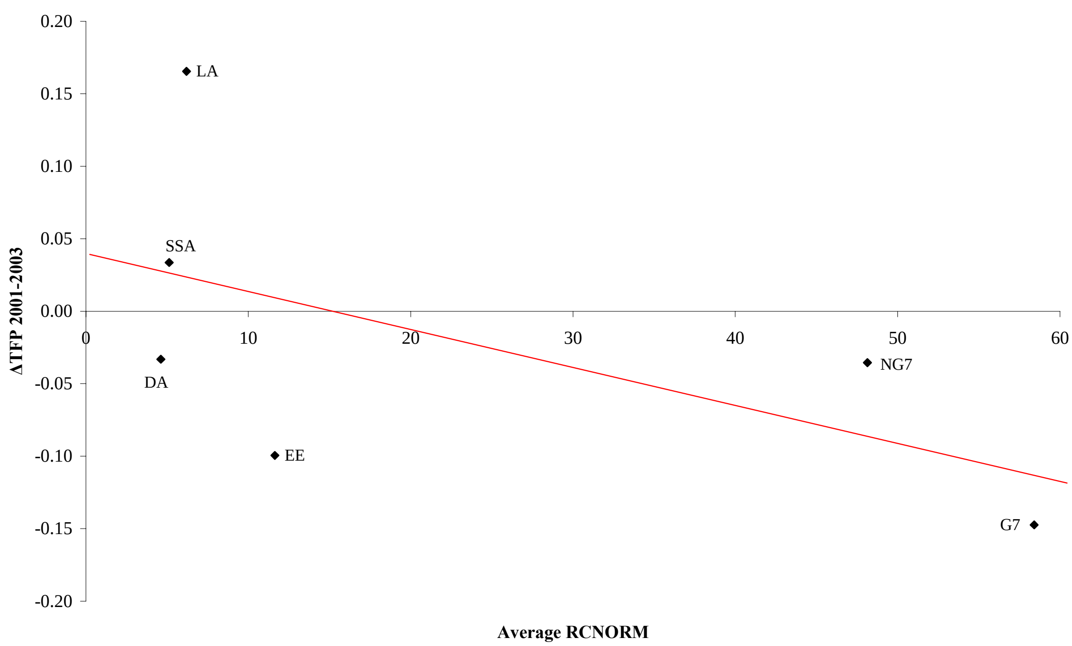


Fig. 2. Regional Welfare-Consistent TFP Change by Average Consumption, 2000–2002



However, the above interpretation considers only alteration to the benefit aspect (utility transformation of output) of the Welfare-Consistent TFP measure. Accordingly, Table 11 is structured to allow scrutiny of the impact that cost changes (normalized consumption weighted by the marginal utility of money) may have on the magnitude of the Welfare-Consistent TFP index. In particular, for a conventional measure of TFP (such as that provided by growth accounting procedures), an increase in real (normalized) consumption would translate into an increase in the TFP index. The converse would be expected to hold for a reduction in real consumption. However, for the Welfare-Consistent measure this need not be the case. The first line of the table suggests the 'typical' case, viz., normalized consumption increases and the benefit of that increase exceeds the cost of production of that output. That is, $\dot{U} > \dot{c} + \dot{\theta}$. But this outcome need not necessarily hold. Table 11 (line 2) shows that Welfare-Consistent TFP allows for the case whereby $\dot{U} < \dot{c} + \dot{\theta}$, viz., the increased utility of additional consumption is less than the associated additional cost. Intuitively, this finding is not surprising as the shadow price of obtaining additional resources increases with the proximity to the production frontier.

Table 11. Potential Welfare-Consistent TFP Income Change Responses

Real income change	Relative utility–marginal cost change	Productivity change
$\dot{RCNORM} > 0$	$\dot{U} > \dot{c} + \dot{\theta}$	$\dot{TFP} > 0$
$\dot{RCNORM} > 0$	$\dot{U} < \dot{c} + \dot{\theta}$	$\dot{TFP} < 0$
$\dot{RCNORM} < 0$	$\dot{U} < \dot{c} + \dot{\theta}$	$\dot{TFP} > 0$
$\dot{RCNORM} < 0$	$\dot{U} > \dot{c} + \dot{\theta}$	$\dot{TFP} < 0$

Note. $\dot{TFP} = \dot{U} - \dot{c} - \dot{\theta}$. $\dot{X} = \ln X_t - \ln X_{t-1}$ where $\dot{X} = \dot{U}, \dot{c}, \dot{\theta}$. $\theta \equiv \partial U(c, p) / \partial c$

Table 11 identifies several cases that may arise from a change in real income in terms of the impact on Welfare-Consistent TFP. To better analyze these changes in the context of the G7 for specific Member Countries the schematic representation of the components of Welfare-Consistent TFP in Fig. 3 is utilized. The cases that arise in practice for the sample period are listed in Table 12.

Fig. 3. Diagrammatic Representation of Welfare-Consistent TFP Decomposition

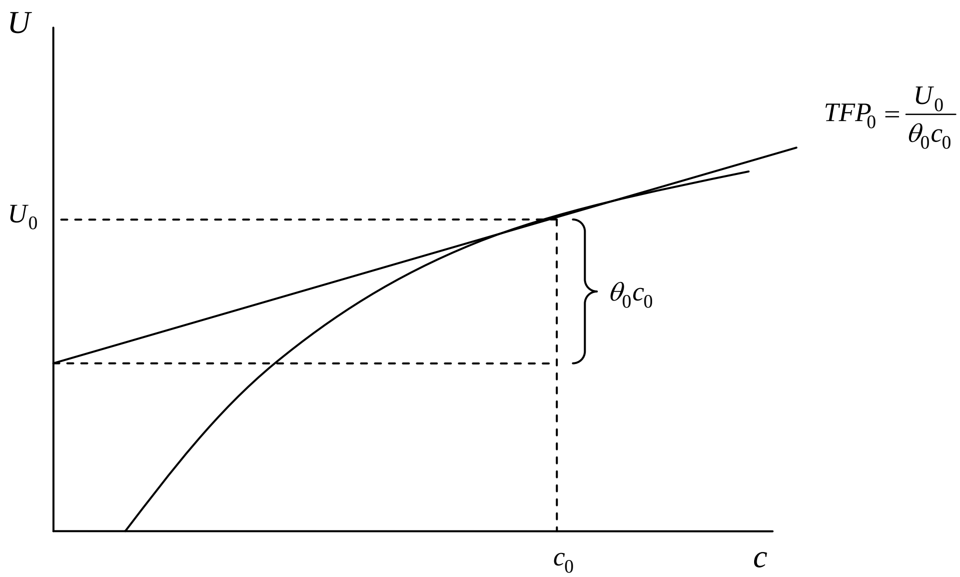


Table 12 clearly indicates that real per capita (normalized) consumption increased for all G7 Member Countries for 2003/2001. The increase in per capita real consumption is on average larger for Group 3. However, for each Member Country reported Welfare-Consistent TFP growth is negative, implying that the benefit from additional consumption is exceeded by the costs of obtaining this additional utility. Further inspection of Table 12 reveals contrasting impacts on Welfare-Consistent TFP for the components (c and θ). In particular, growth in the marginal utility component ($\dot{\theta}$) dominates for Group 1 countries (Japan and the USA) while growth in monetary expenditures ($\dot{c}$) dominates for Group 2 and Group 3 countries. These contrasting impacts are illustrated in Figure 4 and Figure 5. In Figure 4, broad characteristics of the TFP growth decomposition are illustrated for Japan (from $e_{\text{JAPAN,2001}}$ to $e_{\text{JAPAN,2003}}$) and the USA (from $e_{\text{USA,2001}}$ to $e_{\text{USA,2003}}$). In those countries, the influence growth in nominal per capita is modest relative to the influence of growth in the marginal utility of money. Since the latter 'naturally' declines as GDP rises this means that the major effect must be coming from an upward movement of the utility curve with an associated increase in its steepness, as illustrated in Figure 4.

Table 12. G7 Welfare-Consistent TFP Change Decomposition, 2003/2001

Group	G7 Member Country	$R\dot{C}NORM$ (%)	$\dot{U}$ (%)	$\dot{c}$ (%)	$\dot{\theta}$ (%)	$T\dot{F}P^{WC}$ (%)
1	Japan	6.6	36.3	2.9	67.5	–34.1
1	USA	2.6	30.8	6.5	54.6	–30.3
2	United Kingdom	16.0	22.5	22.4	18.7	–18.6
3	Germany	13.1	13.1	25.7	–6.3	–6.3
3	France	24.0	13.0	27.4	–8.3	–6.1
3	Canada	13.1	5.0	17.3	–11.2	–1.1
3	Italy	23.7	21.0	29.6	6.2	–14.8

Note. Countries listed in descending order by η value. $T\dot{F}P = \dot{U} - \dot{c} - \dot{\theta}$. $\dot{X} = \ln X_t - \ln X_{t-1}$ where $\dot{X} = \dot{U}, \dot{c}, \dot{\theta}$. $\theta \equiv \partial U(c,p)/\partial c$

By contrast, Figure 5 broadly shows the TFP growth decomposition for a representative member of Group 3 (France is chosen for this illustration). Here the major influence is an increase in nominal per capita GDP, suggesting a movement along the utility curve from $e_{\text{FRANCE},2001}$ to $e_{\text{FRANCE},2003}$. The marginal utility component (θ) has fallen in the case of France, and this occurs 'naturally' as c increases. Thus there is no evidence that the utility curve for France has actually shifted (or for Canada and Germany). In the case of Italy it is clear that, with positive growth in (θ), the utility curve must have shifted up and become steeper at the year 2003 GDP level. The same is true for the one member of Group 2, the United Kingdom.

Fig. 4. Japan and USA Welfare-Consistent TFP Decomposition, 2003/2001

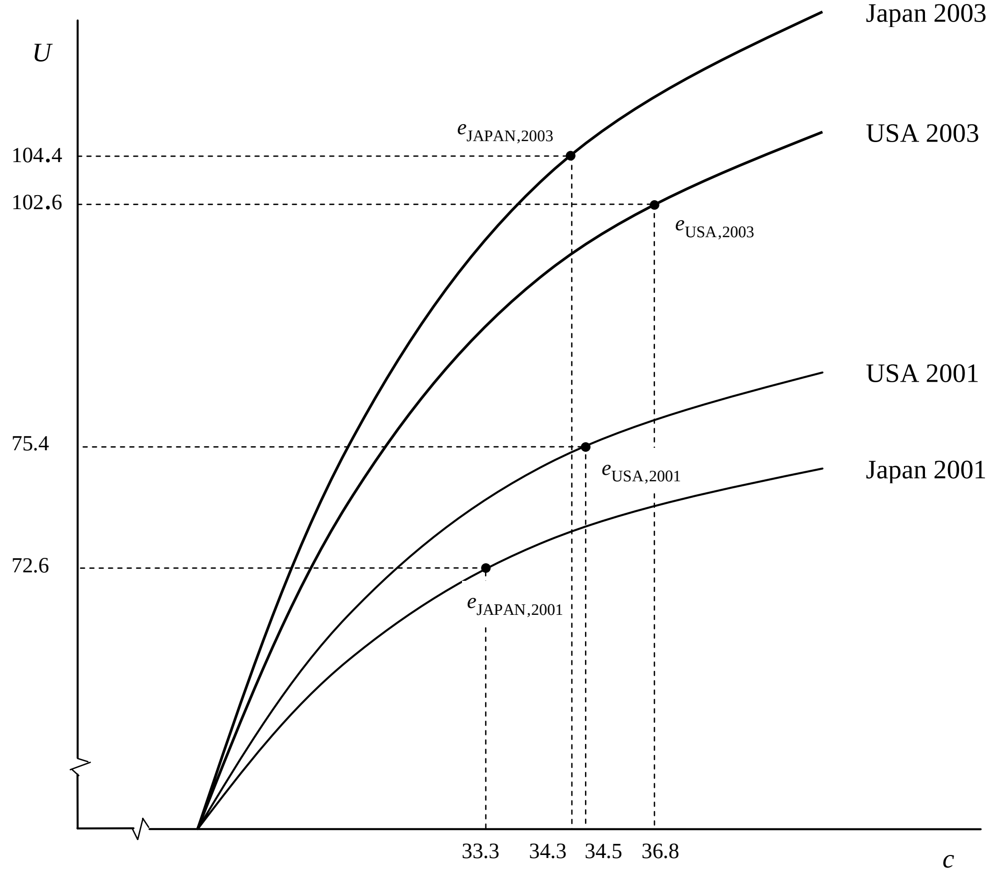
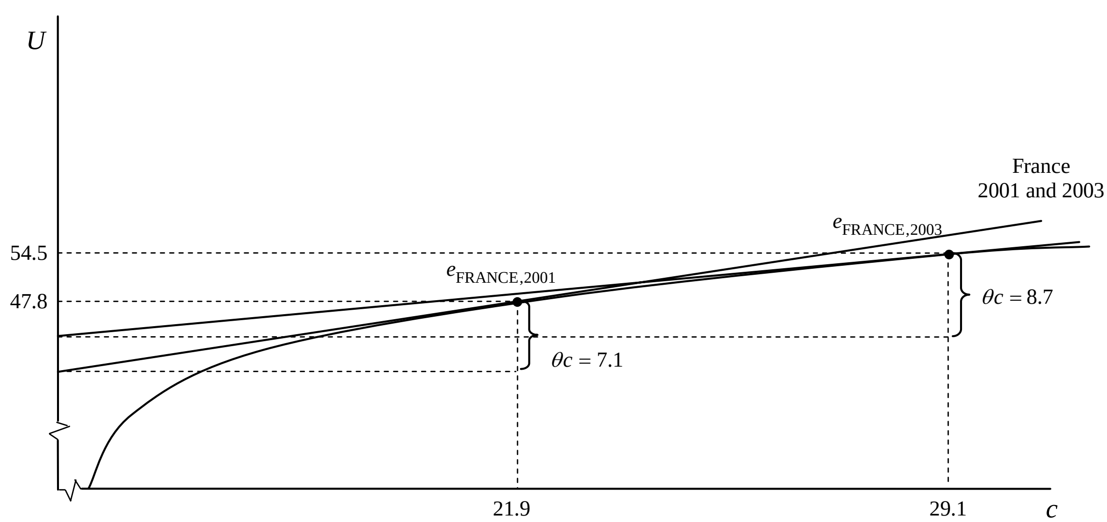


Fig. 5. Representative Group 3 Welfare-Consistent TFP Decomposition, 2003/2001



6. A Sanity Check

The introduction of any new mode of measurement naturally raises questions. First, how well does the introduced measure correspond with the 'reliability' of the existing measure? Second, does the new measure offer sufficient (if any) additional insight into the problem being studied to justify the effort required to seriously consider adoption of the method? In addressing the latter question, the preceding section is suggestive that there may be additional insight gained from considering the proposed Welfare-Consistent TFP measure. However, whether there is correspondence between TFP (conventionally measured) and Welfare-Consistent TFP (as proposed in this study) remains an open question. Accordingly, best practice Conventional TFP estimates for G7 Member Countries are sourced for year 2001 from Jorgenson (2005: Table 3.1) and for year 2003 from Jorgenson and Vu (2005: Table 3). These data are listed in Table 13. The table suggests that Conventionally-Measured TFP is highest for Group 3, followed by Group 2 and Group 1, respectively, for year 2001 (on the utility scale the reverse ordering holds for the Welfare-Consistent measure). However, for neither method does the pattern continue through to 2003.

Table 13. Conventional TFP Estimates

Group	G7 Member Country	2001	2003
1	Japan	86.8	86.7
1	USA	99.5	104.9
2	United Kingdom	96.9	99.8
3	Germany	87.6	89.0
3	France	103.6	104.2
3	Canada	109.7	109.5
3	Italy	102.5	98.9

Source. Countries listed in descending order by η value. Year 2001 data are obtained from Jorgenson (2005: Table 3.1). Year 2003 data are from Jorgenson and Vu (2005: Table 3)

Table 14 is included to allow further comparison of G7 Member Country Conventionally-Measured and Welfare-Consistent TFP estimates for the period 2001–2003. To avoid unit of measure issues the rate of change for both measures are calculated. Of course, any such comparison is limited as national changes in Welfare-Consistent TFP are point estimates obtained from econometric parameter estimates and employing the rule $T\dot{F}P^{WC} = \dot{U} - \dot{c} - \dot{\theta}$, while Conventionally-Measured TFP changes are discrete linear approximations calculated by applying $\Delta TFP^{C}_{2003-2001} = (TFP^{C}_{2003} - TFP^{C}_{2001}) / TFP^{C}_{2001}$. Casual inspection of Table 14 reveals an approximate monotone declining relationship between Welfare-Consistent TFP change and the mean value for $RCNORM$. No corresponding pattern is evident for Conventionally-Measured TFP change. However, further examination indicates a negative sample correlation between Welfare-Consistent TFP and normalized real consumption (–0.798), and a positive correlation with normalized real consumption for Conventionally-Measured TFP (0.597). This finding is encouraging in that both measures are reasonably strongly correlated with normalized real consumption. Not surprisingly, Conventionally-Measured TFP exhibits a positive correlation. The finding of a negative correlation of Welfare-Consistent TFP clearly demonstrates that the curvature of the utility surface (diminishing returns) and the translation of costs into utility, although inherently non-linear, do not eliminate the nexus (as measured by the sample correlation) between TFP and normalized real consumption.

Table 14. Welfare-Consistent and Conventionally-Measured GDP Change, 2001 to 2003

Group	G7 Member Country	RCNORM	$\dot{TFP}^{WC}_{2003/2001}$ (%)	$\Delta TFP^{C}_{2003-2001}$ (%)
1	Japan	75.5	–34.1	–0.1
1	USA	76.2	–30.3	5.4
2	United Kingdom	54.8	–18.6	3.0
3	Germany	52.8	–6.3	1.6
3	France	52.0	–6.1	0.6
3	Canada	52.1	–1.1	–0.2
3	Italy	43.4	–14.8	–3.5

Note. Countries listed in descending order by η value. $\dot{TFP}^{WC} = \dot{U} - \dot{c} - \dot{\theta}$. $\dot{X} = \ln X_t - \ln X_{t-1}$. $\dot{X} = \dot{U}, \dot{c}, \dot{\theta}$. $\theta \equiv \partial U(c,p)/\partial c$. $\Delta TFP^{C}_{2003-2001} = (TFP^{C}_{2003} - TFP^{C}_{2001})/TFP^{C}_{2001}$. *WC* is welfare-consistent. *C* is conventional

7. Conclusions

This study attempts to contribute to the research program recently established by Jorgenson, Landefeld, Nordhaus, Oulton and Weitzman. The analysis, conducted within an inter-temporal optimization framework, argues that the productivity of economic agents should be measured against an economic agent's objectives, viz. welfare as measured by utility. Accordingly, a model based on rational optimizing behavior for a representative agent is used to demonstrate the potential of the approach. The Welfare-Consistent Productivity measure proposed treats utility as output with input measured by the cost of obtaining this utility or GDP evaluated in utility terms. This Welfare-Consistent approach to TFP measurement highlights the importance of welfare—as distinct from output—as the objective. To operationalize the concept productivity measurement is examined within the context of the New Economy debate. This focus is chosen (in particular for the G7 Member Countries) as the productivity rebound of the mid-1990s is a much debated topic (and recent agreement), thus providing a basis from which to sanity check study findings. The empirical findings are encouraging in that empirical estimates of Welfare-Consistent TFP, as proposed here, provide additional insights into productivity not available through Conventionally-Measured TFP. In particular, decomposition of Welfare-Consistent TFP suggests that productivity can fall (rise) with an increase (decrease) in real per capita consumption. The decomposition, when quantified, helps to provide additional insight into the dynamic forces underlying productivity movements. Finally, a post-estimation meta-analysis is undertaken to assess the reliability of the Welfare-Consistent TFP estimates. Not surprisingly, Conventionally-Measured TFP exhibits a positive correlation. The finding of a negative correlation of Welfare-Consistent TFP clearly demonstrates that the curvature of the utility surface (diminishing returns) and the translation of costs into utility, although inherently non-linear, do not eliminate the nexus (as measured by the sample correlation) between TFP and normalized real consumption.

There are several aspects of the analysis, related to data quality, that invite further investigation. First, no price data is available for ICT expenditure shares. However, MAIDS is flexible enough to accommodate this by allowing for non-homothetic Engel curves. Further, of the available data little is in a quality-adjusted form. Another, feature of these data, that when corrected will improve the transparency of the results, is the isolation of exchange rate effects. Several applications of the model are apparent. The most immediate is the conjecture recently raised by Bartelsman and Doms (2000) in their review of productivity modeling with longitudinal data. They claim that, “A lesson to be learned is that one cannot rely on aggregate elasticities in order to compute marginal responses to changes in relevant variables” (Bartelsman and Doms 2000: 586). Clearly, the model developed here—which allows for non-linear Engel curves and non-constant marginal responses—could be used to test this proposition, especially when estimated for comparative purposes on USA national-level (e.g., Jorgenson 2005), industry-level (e.g., Nordhaus 2005) and firm-level (e.g., Brynjofsson and Hitt 2003) data.

Appendix Table 1. Non-G7 National Statistics, 2000–2003

Year	COM	SOFT	HARD	SERV	GDP	POPM	PGDP	RGDPCAP	RCNORM
Region 1–Developing Asia									
India									
2000	12841	358	2257	1120	464603				
2001	12239	456	2764	1386	488645	1032.4	1.000	0.458	1.000
2002	14166	588	3457	1787	517469	1049.5	1.042	0.458	1.000
2003	15861	720	3736	2171	624163	1066.4	1.076	0.526	1.148
Malaysia									
2000	4982	257	1222	287	90161				
2001	3857	303	1229	337	87976	23.8	1.000	3.809	8.317
2002	4367	354	1300	416	94910	24.3	1.038	3.874	8.459
2003	4794	409	1440	522	103161	24.8	1.075	3.983	8.697
Thailand									
2000	3257	161	729	189	122691				
2001	2912	212	769	218	115411	62.3	1.000	1.815	3.963
2002	3161	278	832	254	126883	62.8	1.007	1.965	4.290
2003	3479	368	900	307	142953	63.3	1.026	2.158	4.712
Region 2–Non-G7									
Australia									
2000	13797	2111	5333	5387	376354				
2001	11483	2398	5151	5185	357606	19.5	1.000	17.610	38.450
2002	13356	2699	5072	5570	398228	19.8	1.025	18.913	41.295
2003	16797	2994	5249	5974	505073	20.0	1.055	23.033	50.290
Austria									
2000	5884	1059	2164	2304	190408				
2001	5692	1171	2122	2273	190130	8.1	1.000	23.053	50.334
2002	6022	1291	2130	2450	206049	8.1	1.013	24.641	53.801
2003	7247	1448	2149	2618	253180	8.1	1.029	29.897	65.277
Belgium									
2000	6966	1256	2550	3052	228219				
2001	6485	1393	2591	3075	227150	10.3	1.000	21.784	47.563
2002	6813	1549	2600	3322	245324	10.3	1.018	22.960	50.131
2003	8675	1741	2609	3588	301816	10.4	1.038	27.629	60.325
Denmark									
2000	3872	1086	2246	2639	158053				
2001	3650	1206	2139	2707	159325	5.3	1.000	29.275	63.919
2002	4105	1345	2140	3006	172891	5.3	1.016	31.270	68.275
2003	5026	1495	2212	3249	207030	5.3	1.038	36.595	79.902

Appendix Table 1. Non-G7 National Statistics, 2000–2003 (continued)

Year	COM	SOFT	HARD	SERV	GDP	POPM	PGDP	RGDPCAP	RCNORM
Finland									
2000	4849	839	1687	1567	119784				
2001	4432	933	1743	1607	121286	5.2	1.000	22.708	49.581
2002	5024	1039	1785	1775	131620	5.2	1.010	24.361	53.190
2003	6208	1164	1825	1943	161665	5.2	1.012	29.820	65.109
Greece									
2000	3503	261	802	480	112057				
2001	3515	293	836	487	117114	10.9	1.000	10.344	22.585
2002	4120	321	882	530	133190	11.0	1.039	11.198	24.450
2003	5439	366	945	589	172979	11.1	1.075	13.937	30.430
Hong Kong									
2000	9098	278	1961	540	165362				
2001	8432	318	2007	601	162808	6.7	1.000	24.675	53.876
2002	9423	358	2033	688	161548	6.8	0.964	25.165	54.945
2003	9765	405	2113	810	158592	6.8	0.905	26.265	57.347
Ireland									
2000	3314	355	1139	576	94751				
2001	3341	390	1120	590	102658	3.8	1.000	25.310	55.262
2002	3365	422	1129	637	122067	3.9	1.045	28.378	61.961
2003	3630	464	1172	689	148929	3.9	1.061	34.018	74.275
Israel									
2000	6116	525	1299	1495	114816				
2001	5239	527	1115	1379	112716	6.4	1.000	17.092	37.319
2002	5013	522	1111	1405	103689	6.6	1.041	14.796	32.306
2003	5410	581	1206	1484	108959	6.7	1.045	15.220	33.231
Kuwait									
2000	355	63	92	135	37023				
2001	329	61	100	132	34214	2.4	1.000	15.879	34.670
2002	389	62	104	141	35346	2.4	1.115	14.172	30.943
2003	399	62	111	157	40522	2.5	1.208	14.621	31.924
Netherlands									
2000	11296	3503	4971	5880	370633				
2001	11668	3806	4992	5977	383933	16.0	1.000	22.748	49.668
2002	13202	4158	5011	6548	419632	16.1	1.031	24.056	52.524
2003	16188	4569	4842	6998	512292	16.1	1.061	28.420	62.052

Appendix Table 1. Non-G7 National Statistics, 2000–2003 (continued)

Year	COM	SOFT	HARD	SERV	GDP	POPM	PGDP	RGDPCAP	RCNORM
New Zealand									
2000	4160	245	694	821	50995				
2001	3797	264	651	817	50690	3.9	1.000	12.584	27.476
2002	4665	279	630	819	58559	3.9	0.997	14.513	31.688
2003	6163	298	643	849	77260	3.9	1.024	18.542	40.485
Norway									
2000	4539	886	1653	2381	166797				
2001	3871	981	1710	2447	169968	4.5	1.000	37.232	81.293
2002	4557	1101	1724	2701	190854	4.5	0.984	42.242	92.231
2003	5390	1243	1724	2956	221870	4.5	1.008	47.888	104.559
Portugal									
2000	2735	359	1043	577	106455				
2001	2664	404	1122	580	109868	10.3	1.000	10.175	22.216
2002	3036	447	1182	635	121903	10.4	1.046	10.715	23.395
2003	3852	498	1230	701	147264	10.4	1.070	12.625	27.566
Saudi Arabia									
2000	3327	183	440	545	188721				
2001	3295	185	504	556	183257	20.5	1.000	9.245	20.186
2002	3670	196	530	619	188228	21.2	1.029	8.942	19.524
2003	3889	205	573	714	210478	21.8	1.088	9.173	20.028
Singapore									
2000	6115	489	1495	919	92613				
2001	4729	572	1585	1026	85927	4.1	1.000	21.167	46.216
2002	5077	668	1669	1199	88046	4.2	0.998	21.552	47.057
2003	5613	790	1775	1401	91074	4.2	1.001	21.914	47.847
South Korea									
2000	23966	755	8304	1980	511871				
2001	19289	919	8292	2395	482031	47.5	1.000	10.155	22.172
2002	22197	1116	9386	3153	547156	47.8	1.035	11.060	24.148
2003	25270	1360	9829	3900	605367	48.1	1.065	11.828	25.825
Spain									
2000	13318	1800	4295	3690	561369				
2001	13396	2009	4586	3738	584485	40.3	1.000	13.934	30.424
2002	15570	2242	4819	4061	657038	40.5	1.044	14.895	32.522
2003	19719	2520	5095	4418	838829	40.8	1.086	18.185	39.705

Appendix Table 1. Non-G7 National Statistics, 2000–2003 (continued)

Year	COM	SOFT	HARD	SERV	GDP	POPM	PGDP	RGDPCAP	RCNORM
Sweden									
2000	7329	1778	3745	5068	239567				
2001	6638	1980	3783	5229	219782	8.8	1.000	24.320	53.100
2002	7055	2180	3855	5734	241903	8.8	1.017	26.355	57.544
2003	8580	2452	3866	6280	302539	8.8	1.039	32.312	70.550
Switzerland									
2000	9267	2003	3910	4105	240140				
2001	8565	2231	3918	4052	244768	7.2	1.000	33.925	74.072
2002	10058	2468	3903	4334	268409	7.2	1.016	36.634	79.987
2003	11805	2766	3973	4606	312613	7.2	1.028	42.179	92.094
Region 3–Latin America									
Brazil									
2000	20609	1602	6263	4937	601762				
2001	17691	1698	6404	4792	510094	172.4	1.000	2.754	6.013
2002	17757	1787	7031	5101	460118	174.6	1.102	2.226	4.860
2003	19079	1866	7520	5555	492867	176.9	1.250	2.076	4.533
Chile									
2000	3530	98	563	375	75211				
2001	3080	101	585	366	68418	15.4	1.000	4.296	9.380
2002	3406	102	598	375	67367	15.6	1.045	3.993	8.718
2003	3731	110	589	401	72054	15.8	1.103	3.996	8.725
Columbia									
2000	5805	158	722	424	83786				
2001	5631	168	687	414	81735	43.1	1.000	1.786	3.900
2002	5951	175	691	431	81213	43.8	1.064	1.639	3.579
2003	5724	198	705	456	77435	44.6	1.152	1.419	3.098
Costa Rica									
2000	839	67	104	82	15962				
2001	865	74	121	90	16397	3.9	1.000	3.881	8.474
2002	906	80	132	102	16835	4.0	1.091	3.580	7.817
2003	962	89	143	113	17476	4.0	1.179	3.375	7.369
Ecuador									
2000	306	11	118	28	13564				
2001	550	15	141	33	17897	12.9	1.000	1.105	2.413
2002	650	18	159	39	20695	13.1	1.118	1.122	2.450
2003	731	23	190	49	22852	13.4	1.219	1.116	2.437

Appendix Table 1. Non-G7 National Statistics, 2000–2003 (continued)

Year	COM	SOFT	HARD	SERV	GDP	POPM	PGDP	RGDPCAP	RCNORM
Honduras									
2000	173	19	36	24	6025				
2001	169	22	43	27	6400	6.6	1.000	0.900	1.965
2002	190	24	46	31	6580	6.7	1.063	0.850	1.856
2003	204	27	51	35	6937	6.9	1.144	0.812	1.773
Mexico									
2000	12803	564	3144	1758	580581				
2001	12673	549	3323	1702	621488	99.1	1.000	5.926	12.939
2002	13293	611	3740	1845	647375	100.8	1.070	5.675	12.391
2003	12813	633	4096	1999	625989	102.5	1.160	4.972	10.856
Panama									
2000	725	101	123	95	9928				
2001	671	111	137	103	10088	2.9	1.000	3.427	7.483
2002	755	114	139	110	10436	3.0	1.017	3.422	7.472
2003	788	124	147	120	11010	3.0	1.021	3.533	7.714
Peru									
2000	2751	110	523	302	53120				
2001	2573	115	498	288	53237	26.3	1.000	1.993	4.352
2002	2808	117	522	292	56007	26.7	1.006	2.052	4.480
2003	3118	141	574	329	60557	27.1	1.029	2.138	4.668
Uruguay									
2000	950	38	143	106	20075				
2001	805	36	133	93	18557	3.3	1.000	5.273	11.513
2002	566	43	160	112	12282	3.4	1.186	2.926	6.389
2003	537	33	130	91	11191	3.4	1.405	2.239	4.889
Venezuela									
2000	3062	151	599	558	121246				
2001	3090	162	635	548	126150	24.6	1.000	4.743	10.356
2002	2836	177	631	589	95460	25.1	1.330	2.648	5.782
2003	2947	204	625	660	89035	25.5	1.794	1.799	3.928
Region 4—Eastern Europe									
Czech Republic									
2000	2580	293	701	633	51434				
2001	2420	334	778	650	57186	10.2	1.000	5.341	11.662
2002	3230	380	836	725	69514	10.2	1.028	6.319	13.797
2003	3748	434	890	806	85384	10.2	1.054	7.563	16.513

Appendix Table 1. Non-G7 National Statistics, 2000–2003 (continued)

Year	COM	SOFT	HARD	SERV	GDP	POPM	PGDP	RGDPCAP	RCNORM
Hungary									
2000	2153	272	536	464	46666				
2001	1845	303	582	474	52183	10	1.000	4.820	10.524
2002	2443	344	652	543	65185	10	1.089	5.534	12.083
2003	3250	414	732	662	83118	9.9	1.164	6.638	14.493
Poland									
2000	4451	415	1413	743	166548				
2001	4674	472	1613	794	186422	38.6	1.000	4.639	10.129
2002	5392	537	1859	908	192204	38.6	1.013	4.724	10.314
2003	5881	604	1991	1016	210812	38.5	1.018	5.170	11.288
Slovak Republic									
2000	773	83	194	144	20217				
2001	793	94	221	152	20884	5.4	1.000	3.727	8.138
2002	882	105	238	175	24188	5.4	1.040	4.151	9.063
2003	1200	109	229	183	32519	5.4	1.088	5.326	11.629
Region 5–Sub-Saharan Africa									
South Africa									
2000	6896	627	1661	1293	128106				
2001	5845	724	1707	1351	114876	45.5	1.000	2.346	5.122
2002	5772	800	1698	1486	106585	46.1	1.103	1.947	4.251
2003	8430	934	1782	1711	159974	46.7	1.152	2.76	6.026

Appendix Table 2. Non-G7 Utility and Time Varying Parameter Estimates

Year	Utility	$\partial U / \partial c$	$\partial^2 U / \partial c^2$	ϕ	η	TFP
Region 1–Developing Asia						
India						
2001	1.000	1.000	0.000	1.000	0.500	1.000
2002	1.000	0.959	0.031	1.001	0.483	1.002
2003	1.148	0.919	–0.082	0.997	0.542	1.009
Malaysia						
2001	8.317	0.501	–0.025	0.973	0.604	2.123
2002	9.200	0.614	–0.021	0.972	0.525	1.814
2003	9.086	0.549	–0.020	0.972	0.547	1.884
Thailand						
2001	3.963	0.514	–0.063	0.993	0.693	1.969
2002	4.109	0.485	–0.056	0.993	0.699	1.985
2003	4.304	0.453	–0.047	0.993	0.700	1.988
Region 2–Non-G7						
Australia						
2001	38.450	0.347	–0.006	0.983	0.751	2.868
2002	42.705	0.386	–0.005	0.981	0.719	2.598
2003	46.951	0.348	–0.004	0.981	0.712	2.527
Austria						
2001	50.334	0.329	–0.004	0.987	0.784	3.088
2002	52.752	0.329	–0.004	0.987	0.775	2.992
2003	59.593	0.321	–0.003	0.986	0.756	2.805
Belgium						
2001	47.563	0.332	–0.005	0.987	0.783	3.064
2002	49.986	0.338	–0.004	0.987	0.771	2.943
2003	56.082	0.328	–0.003	0.986	0.752	2.773
Denmark						
2001	63.919	0.311	–0.003	0.988	0.804	3.250
2002	68.771	0.328	–0.003	0.987	0.787	3.057
2003	71.161	0.279	–0.002	0.987	0.792	3.110
Finland						
2001	49.581	0.327	–0.004	0.984	0.785	3.069
2002	54.983	0.368	–0.004	0.983	0.756	2.792
2003	56.732	0.298	–0.003	0.983	0.769	2.902

Appendix Table 2. Non-G7 Utility and Time Varying Parameter Estimates (continued)

Year	Utility	$\partial U / \partial c$	$\partial^2 U / \partial c^2$	ϕ	η	TFP
Greece						
2001	22.585	0.365	–0.010	0.989	0.746	2.728
2002	24.246	0.370	–0.008	0.989	0.726	2.573
2003	26.249	0.311	–0.006	0.989	0.728	2.573
Hong Kong						
2001	53.876	0.323	–0.004	0.987	0.819	3.256
2002	57.920	0.382	–0.005	0.986	0.795	3.011
2003	46.225	0.228	–0.004	0.991	0.882	4.124
Ireland						
2001	55.262	0.327	–0.004	0.986	0.754	2.993
2002	66.425	0.394	–0.003	0.985	0.703	2.545
2003	99.627	0.636	–0.004	0.982	0.604	1.944
Israel						
2001	37.319	0.334	–0.006	0.984	0.799	3.026
2002	43.805	0.556	–0.009	0.979	0.712	2.363
2003	39.911	0.438	–0.008	0.981	0.755	2.651
Kuwait						
2001	34.670	0.392	–0.008	0.996	0.743	2.877
2002	31.162	0.319	–0.007	0.996	0.774	3.191
2003	27.518	0.200	–0.004	0.997	0.840	4.013
Netherlands						
2001	49.668	0.324	–0.004	0.985	0.775	3.032
2002	51.079	0.310	–0.004	0.985	0.771	2.992
2003	53.871	0.269	–0.003	0.985	0.772	2.988
New Zealand						
2001	27.476	0.358	–0.008	0.974	0.772	2.784
2002	32.150	0.415	–0.008	0.971	0.725	2.442
2003	35.330	0.348	–0.005	0.970	0.726	2.437
Norway						
2001	81.293	0.288	–0.003	0.991	0.841	3.547
2002	101.450	0.389	–0.003	0.989	0.786	2.936
2003	106.817	0.355	–0.002	0.989	0.784	2.917

Appendix Table 2. Non-G7 Utility and Time Varying Parameter Estimates (continued)

Year	Utility	$\partial U / \partial c$	$\partial^2 U / \partial c^2$	ϕ	η	TFP
Portugal						
2001	22.216	0.366	–0.010	0.989	0.737	2.697
2002	23.306	0.363	–0.008	0.989	0.722	2.587
2003	24.773	0.321	–0.006	0.989	0.723	2.578
Saudi Arabia						
2001	20.186	0.396	–0.013	0.995	0.741	2.704
2002	18.882	0.341	–0.012	0.995	0.771	2.947
2003	17.194	0.239	–0.008	0.996	0.829	3.528
Singapore						
2001	46.216	0.328	–0.005	0.983	0.827	3.202
2002	52.535	0.423	–0.006	0.980	0.782	2.779
2003	46.223	0.313	–0.005	0.984	0.831	3.245
South Korea						
2001	22.172	0.353	–0.011	0.988	0.817	2.928
2002	25.516	0.415	–0.011	0.986	0.765	2.542
2003	25.178	0.355	–0.009	0.986	0.782	2.667
Spain						
2001	30.424	0.354	–0.007	0.990	0.740	2.800
2002	31.872	0.343	–0.006	0.990	0.730	2.711
2003	34.269	0.292	–0.004	0.989	0.730	2.694
Sweden						
2001	53.100	0.340	–0.004	0.982	0.757	2.970
2002	47.225	0.228	–0.003	0.985	0.812	3.581
2003	53.393	0.225	–0.002	0.984	0.787	3.265
Switzerland						
2001	74.072	0.312	–0.003	0.985	0.810	3.296
2002	85.064	0.369	–0.003	0.983	0.773	2.911
2003	87.127	0.317	–0.002	0.983	0.780	2.977
Region 3–Latin America						
Brazil						
2001	6.013	0.506	–0.015	0.975	0.462	1.902
2002	5.276	0.438	–0.017	0.976	0.499	2.166
2003	4.907	0.331	–0.017	0.976	0.573	2.520

Appendix Table 2. Non-G7 Utility and Time Varying Parameter Estimates (continued)

Year	Utility	$\partial U / \partial c$	$\partial^2 U / \partial c^2$	ϕ	η	TFP
Chile						
2001	9.380	0.439	–0.023	0.982	0.677	2.276
2002	9.129	0.441	–0.023	0.983	0.673	2.271
2003	8.442	0.331	–0.020	0.985	0.741	2.648
Columbia						
2001	3.900	0.531	–0.040	0.970	0.575	1.830
2002	3.735	0.516	–0.038	0.970	0.572	1.848
2003	3.420	0.470	–0.042	0.971	0.605	1.982
Costa Rica						
2001	8.474	0.454	–0.018	0.974	0.575	2.096
2002	8.046	0.410	–0.017	0.974	0.589	2.188
2003	7.693	0.366	–0.015	0.975	0.608	2.302
Ecuador						
2001	2.413	0.501	–0.045	0.994	0.575	1.642
2002	2.336	0.372	–0.051	0.994	0.695	1.887
2003	2.323	0.337	–0.044	0.994	0.705	1.909
Honduras						
2001	1.965	0.629	–0.075	0.992	0.575	1.522
2002	1.898	0.608	–0.064	0.993	0.563	1.515
2003	1.828	0.547	–0.073	0.993	0.606	1.577
Mexico						
2001	12.939	0.397	–0.016	0.992	0.703	2.459
2002	13.649	0.456	–0.016	0.992	0.656	2.205
2003	12.559	0.421	–0.016	0.992	0.673	2.314
Panama						
2001	7.483	0.503	–0.023	0.959	0.575	2.036
2002	7.646	0.527	–0.022	0.958	0.553	1.955
2003	7.505	0.471	–0.022	0.959	0.586	2.067
Peru						
2001	4.352	0.554	–0.030	0.973	0.517	1.840
2002	4.517	0.586	–0.025	0.973	0.487	1.743
2003	4.584	0.554	–0.025	0.972	0.498	1.757

Appendix Table 2. Non-G7 Utility and Time Varying Parameter Estimates (continued)

Year	Utility	$\partial U / \partial c$	$\partial^2 U / \partial c^2$	ϕ	η	TFP
Uruguay						
2001	11.513	0.481	–0.009	0.970	0.460	2.039
2002	9.073	0.499	–0.010	0.972	0.429	2.355
2003	7.777	0.342	–0.013	0.972	0.534	3.249
Venezuela						
2001	10.356	0.453	–0.013	0.986	0.531	2.115
2002	8.088	0.418	–0.013	0.988	0.518	2.410
2003	6.613	0.253	–0.014	0.989	0.653	3.549
Region 4—Eastern Europe						
Czech Republic						
2001	11.662	0.451	–0.014	0.968	0.587	2.185
2002	13.861	0.518	–0.011	0.967	0.525	1.860
2003	15.012	0.460	–0.008	0.967	0.534	1.846
Hungary						
2001	10.524	0.438	–0.015	0.973	0.595	2.176
2002	12.946	0.538	–0.011	0.972	0.498	1.741
2003	14.439	0.483	–0.008	0.971	0.495	1.687
Poland						
2001	10.129	0.435	–0.020	0.988	0.655	2.282
2002	10.566	0.467	–0.019	0.987	0.630	2.152
2003	9.944	0.340	–0.016	0.988	0.703	2.529
Slovak Republic						
2001	8.138	0.493	–0.015	0.974	0.504	2.013
2002	8.477	0.445	–0.013	0.974	0.515	2.006
2003	9.912	0.426	–0.009	0.973	0.493	1.824
Region 5—Sub-Saharan Africa						
South Africa						
2001	5.122	0.529	–0.011	0.959	0.421	1.815
2002	4.624	0.480	–0.011	0.960	0.431	1.971
2003	5.361	0.395	–0.010	0.956	0.471	1.876

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