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ICT Diffusion and Productivity in OECD Economies and New Zealand's Industrial Sectors[1]

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Abstract: We compare measures of total factor productivity (TFP) to independent measures of ICT diffusion and technological change in New Zealand and a collection of OECD countries. The measures of technological change are investment quality (investment specific technological change or IST) and direct measures of ICT diffusion available in aggregate and in the industrial data for New Zealand. TFP growth is generally uncorrelated and sometimes negatively correlated with the independent measures of technological change. These findings are consistent with two views. First that TFP is not a measure of technological change but ideally (often not operationally) is a measure of free lunches associated with such change. Second, that the productivity bonuses from technological change usually occur with significant temporal lags. Thus, TFP is not a contemporaneous measure of the free lunches from technological change. We conclude that New Zealand is experiencing a similar growth phenomenon to that of many other OECD economies. The general purpose technology of electronic ICT has been diffusing since the mid- - 1970's through a costly investment process that requires many complementary investments to exploit the economic potential of this GPT and the productivity benefits are only recently emerging in most cases. We also conclude that the recent low productivity growth in New Zealand is not necessarily cause for alarm from policy makers. This is because New Zealand like many other OECD economies is investing in technology that has a potentially high future output payoff even if it is not measurable in the TFP statistic.

Keywords: ICT diffusion, Total Factor Productivity, Investment specific technological change

1. INTRODUCTION

A fundamental question for those who study and make policy decisions with respect to economic growth is whether the GPT of modern electronically derived ICT and its multitude of ancillary and complementary technologies together have caused a revolution in production, communication and more broadly societies and cultures, globally? The issue is contentious. In this paper we argue using a combination of pre-existing theory and our analysis of empirical evidence available in New Zealand and the OECD that the answer is yes, at least with respect to productivity and communication. The evidence for this revolution is not found in any single scalar measure such as productivity, but, rather in a number of independent measures (qualitative as well as quantitative) of the actual technological change and its impact. Separating the diffusion of this transforming general purpose technology (GPT) from measured output or productivity gains generated by it is therefore critical.[2] Such a separation is one of the novel contributions of this paper relative to others that have addressed the productivity slow down with traditional productivity analysis. By utilizing a theory of endogenous, technology driven growth which can interpret these separate measures in a coherent framework we also provide a tool that

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[2] Lipsey, Carlaw and Bekar (2005) define transforming GPTs as those that "lead to massive changes in many, sometimes most, characteristics of the economic, social, and political structures."

potentially can be used to identify possible avenues for policy intervention designed to improve the economic performance.

There is little disagreement that computers, programmable computing networks (PCN)[3] (including the Internet) and the myriad supporting complementary technologies that they have enabled, have revolutionized production into the global economy.[4] However, debate persists on whether this technological revolution is creating a social and economic revolution similar to those of the First and Second Industrial Revolutions, with most dissenting views based on neoclassical theoretical interpretations of measures of productivity as the evidence that computers and ICT are not as important as the technologies that drove the earlier revolutions.[5]

Economic historians and students of technology agree that technological change is *the* major determinant of very long-term economic growth (i.e., across the millennia). Yet, over shorter periods, there is debate over what proportion of measured economic growth is due to technological change and what to other forces, such as the accumulation of physical and human capital. Such debates imply that we are able to separate the ultimate effects of technological change from their embodied and proximate effects.[6] This separation is only possible under the theoretical fiction of an aggregate production function because it assumes the existence of generic indexes of labour, capital and the state of technology, and facilitates the easy calculation of productivity growth. Often such assumptions are viewed as sufficient to interpret productivity growth to be a measure of technological change. However, as Carlaw and Lipsey (2003), Lipsey and Carlaw (2004) and Lipsey, Carlaw and Bekar (2005) note this is not the case. In their view, most technological knowledge must become embodied in some real physical component of the work whether it is physical or human capital (including all tacit skills), laws and legal institutions, or social and cultural norms in order to become productively useful. Furthermore, each of these embodiments requires costly investment. Thus, the separation of the contribution of technological change from the contribution of measured factors such as physical and human capital to economic growth is difficult.

Keys to connecting technological change to economic growth lie in identifying specific embodiments of new technology, finding independent measures of these embodiments and determining their contribution to economic growth over a long time horizon.

At the centre of the debate concerning ICT's impact on economic growth is the so called productivity paradox – a combination of a number of stylised and anecdotal observations about the proliferation of computers and ICT with the statistical observation of a decline in the growth rate of total factor productivity (TFP) in many OECD countries, starting in the early 1970s and running through to the middle of the 1990s. The erroneous presumption that underwrites the paradox is that TFP measures technological change in a perfectly, contemporaneously correlated fashion. This interpretation finds its theoretical footing in the neoclassical models of economic growth which employ the concept of the aggregate production function that date back to Solow (1956). In such models it is explicitly assumed that technological change acts as a parameter which instantaneously shifts the aggregate production when such change occurs.

This aggregate production function approach is a simplification of a much broader concept of the aggregate production function that allows for the resource consuming activities of R&D. Examples include, Jorgenson and Griliches (1967), Jorgenson (2001), and Barro (1999), whose approaches involve intermediate production functions, or a meta production possibilities frontier. Two critical features of these approaches are their treatment of R&D as an input and the returns to scale in production functions (or overall production possibilities set). Jorgenson and Griliches (1967) and Jorgenson (2001) treat all lines of

[3] For a full definition of PCN see Carlaw, Lipsey and Webb (2007). Throughout this paper we use the term ICT tp refer to the GPT, however, the GPT is more appropriately identified as PCN.
[4] However, some economist, such as, Young (1992) and Krugman (1996) commenting on Young argue that the lack of high total factor productivity in the Asian economies that experience exceptional growth in GDP per capita through the 1970s and 1980s is evidence that no technological revolution occurred in these economies.
[5] See for example Gordon (2000) and Tripplet (1999)
[6] Of course, technological change and investment are interrelated, the latter being the main vehicle by which the former enters the production process.

production activities as having constant returns to scale, which implies that the part of technological change that involves costly R&D is not measured by changes in TFP. In contrast, Barro (1999) uses production functions that allow R&D to generate expanding product variety or quality with increasing returns to the intermediate R&D inputs. In Barro's case, because of the increasing returns to the intermediate R&D input, there is a Hicks neutral, "Mana from heaven" component of technological change that is measured by changes in TFP and a component of the endogenous technological change generated from costly R&D that is not. All of this leaves open the questions about the meta or all encompassing notion of the aggregate production function and about the appropriate formulation of R&D and knowledge production.

Many of the more recent studies analysing the impact of ICT on economic and productivity growth also utilise this aggregate production function framework. (See e.g., Jorgenson and Stiroh, 2000; Oliner and Sichel, 2000; Schreyer 2000; and Skoczylas and Tissot 2004) They also utilise the traditional national income and expenditure accounts industrial classification categories to identify things like the "ICT sector" of the economy, which is typically defined as the ICT producing sector. (see for example, Pilat and Lee, 2001, who provide an overview of uses of OECD data to measure the impact of ICT on productivity change). These studies for the most part find a surge in productivity in the late 1990's particularly in the US but have difficulty attributing this surge to the ICT sector or to ICT using industries such as those in the service sectors of the OECD economies studied. We argue that there are two basic problems with this approach both owing to the fact that ICT is a GPT. First, as has been argued in Carlaw and Lipsey (2003) and Lipsey and Carlaw (2004), new investment in a new technology is not necessarily contemporaneously correlated with increases in output or productivity. According to Carlaw and Lipsey (2003) and Lipsey and Carlaw (2004) TFP change is ideally a measure of the free lunches associated with technological change but with the caveat that it often does not measure even these properly. TFP change is not a measure of technological change. Second, ICT is not contained (and therefore not measurable) in a single sector of an economy. Rather, its general purpose nature implies that it pervades and impacts on all sectors of the economy and may not lead to any kind of measurable productivity increase. We address both of these issues in this paper. To so requires us to summarise the literature on the subject of GPT driven economic growth.

2. GPT-DRIVEN GROWTH THEORY

The GPT concept was invented by Bresnahan and Trajtenberg in (1992), however, the concept of structured technology dates at least back to Nelson and Winter (1980), Freeman and Perez's (1982) and Freeman and Louca's (2001) Technoeconomic Paradigms and Mokyr's (1990) Macro Inventions. Helpman's (1998) volume on long run growth and GPTs is a collection of the first generation of GPT growth models which were inspired by the earlier work of Bresnahan and Trajtenberg. Since Helpman's book very little has been done to advance the state of GPT theorising with the exception of Carlaw and Lipsey (2001, 2006 and 2007) and Chapters14 and 15 of Lipsey, Carlaw and Bekar (2005). Part of the problem for further development has been that need to step out of the traditional mould of modelling economic growth as a stationary equilibrium concept. Carlaw and Lipsey (2001) first introduced a non-stationary equilibrium concept into GPT modelling and have refined the model to include a number of complexities that the first generation of GPT models could not. The model requires computer simulation to solve to the transitional equilibrium in each time period and is also consistent with the stylized growth facts presented in Jones (1998).

Two models: a basic three sector model, and a four sector model that includes structural adjustment costs, both taken from Lipsey, Carlaw and Bekar (2005) are used by Carlaw (2004) and Carlaw and Lipsey (2005) to assess measures of ICT diffusion in Australia relative to measured TFP. In the models, a sequence of GPTs arrive each at uncertain times and with uncertain productive impacts that diffuse according to a logistic process. The models assume behaviour that results in resource allocations such that a non-stationary equilibrium is generated, which is consistent with observed growth through time. The models have the property that in the absence of future GPTs there are diminishing returns and growth asymptotically approaches zero. But the arrival of new GPTs rejuvenates and sustains the growth process.

Because these models require a numerical solution procedure that is iterated through several periods they provide an opportunity for Monte Carlo analysis of the assumptions that underlay both endogenous growth modelling and TFP growth calculations. Carlaw (2004) and Carlaw and Lipsey (2005) undertake such exercises and confirm the arguments of Carlaw and Lipsey (2003) and Lipsey and Carlaw (2004) that TFP is not a measure of technological change. Under assumptions of zero structural adjustment costs, TFP is positively correlated with direct measures of technological change. However, it persistently under estimates such technological change. Under conditions of positive structural adjustment costs, TPF growth is negatively correlated with measured technological change and persistently underestimates technological change when a new GPT arrives and overestimates technological change as the GPT matures. In both models TFP change fails to detect the arrival of the big technological shocks of GPTs.

In this paper we use the Lipsey, Carlaw and Bekar (2005) models to interpret the empirical evidence for a set of sixteen OECD economies and nine industrial sectors in New Zealand which show that the pattern of ICT diffusion and measured TFP change are either uncorrelated or negatively correlated.

3. THE NEW ZEALAND DATA

The theoretical framework of Carlaw and Lipsey (2001 and 2006) and Lipsey, Carlaw and Bekar (2005) affords the luxury of observing the growth of technological knowledge directly and independently of output and TFP growth. In real data, however, few such direct measures are available. We therefore adopt two alternative, proximate measures of the rate of technological diffusion. Both have the virtue that they are independent of output growth. But, they are also flawed for a number of reasons discussed below.

The contributions of embodied technological change to TFP growth have been studied in the growth accounting literature. Hulten (1992) and Jorgenson (1966) have focused on the measurement of the efficiency of the capital stock and the effects of measurement errors on productivity estimates. These authors argue that quality change (or Investment Specific Technological (IST) change growth) is difficult to observe, and therefore may not be measured accurately in the National Income and Product Accounts (NIPA). In order to obtain an estimate of the size of error associate with the official capital stock estimates, Hulten used quality-corrected data from Gordon (1990). Gordon found that the official deflators for producer durable equipment overstate quality-corrected inflation in capital goods, and therefore understate increases in capital input.

Following Greenwood et al (1997 and 2000), Carlaw and Kosempel (2004) adopt a computable general equilibrium approach to measuring changes in the quality of investment in Canada. They demonstrate that investment specific technological change (IST) made important contributions to Canadian output growth during the 1961-96 period. One of their key findings is that IST is negatively correlated with TFP since 1974.

IST is calculated by making the unrealistic assumption that the economy, sector or industry under examination in is a perfectly competitive general equilibrium which has become characterized as the Ramsey-Cass-Koopmans model following the pioneering work of Ramsey (1928) Cass (1965) and Koopmans (1965). In this framework the microeconomic decisions of consumers determine the saving rates, levels of consumption and stocks of capital in the economy whose aggregate production capacity is characterised by a constant returns to scale production function defined over capital and labour.[7]

[7] It is important to note that the assumption of constant returns to scale is one on which the entire calculation depends. In the absence of constant returns to scale it is not clear that IST is solely a measure of investment quality. We maintain the assumption here and use the measure as being indicative of the point that TFP does not measure changes in technology. Though this likely implies that our independent measure of technological change, IST, is itself flawed.

Within such a framework, constant income share weights but an increasing capital to labour ratio can only be reconciled by an increasing quality of capital, which is the result that Carlaw and Kosempel (2004) verify empirically. In their analysis the measure of residual neutral technological change, which would be equal to TFP in the absence of increases in investment quality, is negative over much of the period from 1974 onward. They interpret this negative measure to potentially indicate a structural adjustment cost associated with the adoption of the new technology implicit in the high quality capital investments of the sort discussed by David (1990) and Lipsey, Bekar and Carlaw (1998b).

We report here some of our follow up analysis of changes in investment quality and changes in TFP in sixteen OECD countries (where comparable data on national accounts, labour and productivity was available from the OECD) reveals that the negative relationship between IST and TFP change appeared in most of the countries in the data set. The data span the period 1970 to 1997, although the times series are not as long for some countries included in the analysis. Correlations and their significance are calculated by linearly regressing TFP growth on IST growth. This simple procedure allows for easy calculation of correlation and the statistical significance of the correlation between the two rates of change, however, it also has some obviously flawed assumptions. For example, it is unlikely that the relationship between TFP and IST growth is linear. We use it because reveals that there is clearly something wrong with TFP as a contemporaneous measure of technological change. We report these results in Table 3.1.

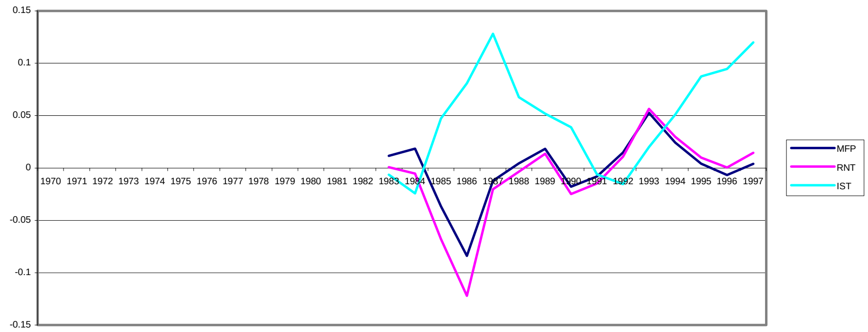
Table 3.1

	Correlation	**Significance (t statistic)**	**Ave. TFP growth**	**Ave. IST growth**
Australia	-0.20	-1.63	0.57%	3.06%
Austria	0.08	0.80	1.62%	1.46%
Canada	-0.04	-0.45	0.49%	6.69%
Germany	-0.90	-1.91	0.24%	1.00%
Denmark	0.06	0.49	0.66%	1.37%
Spain	-0.17	-1.19	0.70%	1.75%
Finland	-0.35	-1.49	0.99%	0.12%
France	0.09	0.66	0.89%	2.23%
United Kingdom	-0.36	-3.45	0.82%	1.11%
Greece	-0.12	-2.57	0.09%	2.57%
Ireland	-0.05	-0.35	1.55%	1.72%
Italy	-0.03	-0.18	0.53%	1.08%
Japan	0.43	2.93	0.96%	3.97%
Netherlands	0.29	2.30	-0.002%	1.75%
New Zealand	-0.22	-1.30	-0.09%	4.90%
Sweden	0.06	0.56	0.40%	2.05%

The results shown in Table 3.1 indicate that the temporal relationship between TFP and IST is not positively correlated. In most cases there is a negative relationship, in two cases a significant one. Only in two cases is there a significant positive relationship. Given the assumptions necessary to make these calculations we do not draw any strong conclusions. But we take this as weak evidence that there is no relationship between our independent measure of technological change and TFP growth. There is possibly a negative relationship over the period examined at least for some economies.

New Zealand is one of the countries which have a negative correlation between TFP and IST change. However, the relationship is not statistically significant for the available data. However, the time series used in the Analysis for New Zealand is quite short (1988-1999) and this no doubt impacts the statistical significance of the coefficient. What is obvious from the Figure 3.1 is that the TFP and IST change appear to move in opposite directions for large parts of the time period.

Figure 3.1: IST and MFP change, New Zealand



What is also obvious from Figure 3.1 is that IST and TFP change has diverged markedly twice in the period, first in beginning in 1984 and continuing until 1992 and again beginning 1993 and continuing until the end of the sample. These dates have obvious significance in New Zealand history. An a possible explanation is that these two periods of regulatory reform sparked investment in higher quality capital which caused productivity to fall but improved the quality of productive technology in New Zealand.

Data produced by Statistics New Zealand and the New Zealand Treasury provide an opportunity to calculate IST growth and compare it to TFP growth at a somewhat disaggregated, industrial level. The data include measures of gross fixed capital formation and their price series by industrial category at approximately the 1 digit ANZSIC level.[8] From these data it is possible to calculate the rate of IST change and compare the diffusion rates to the rate of TFP growth within each industrial sector.

To see the degree of correlation between the rates of IST and TFP change in each industry we again linearly regress TFP growth on IST change for the period 1989-1999 for nine industrial sectors, noting again the flawed assumptions of a linear relationship between TFP growth and the rate of IST change. [9] We use this technique here because it reveals that there is clearly something wrong with TFP as a contemporaneous measure of technological change. Table 3.2 reports the correlation coefficients and *t* statistics for each sector.

Two things are immediately obvious in this analysis. First, in many cases TFP growth is on average below the rate of IST change. Second, the rate of IST change in many sectors appears to be uncorrelated or negatively correlated with the rate of TFP change. Some of the industrial sectors analyzed (all except Mining and quarrying and construction) show a clear increase in IST growth after 1993. In many cases this increase IST growth coincides with a growth rate slow down in TFP. For example Manufacturing, Electricity, gas and water, Business and property services, Personal and community service and Retail and wholesale trade all show a divergence between IST and TFP growth after 1993. In addition, other data on ICT diffusion show the period following from 1993 to be a watershed in New Zealand. Investment in ICT appears to have been at its peak during this period (at least as

[8] Gross fixed capital formation is calculated by Statistics New Zealand using a chain volume methodology. Treasury has aggregated 31 industrial sectors at the 1 digit ANZSIC level into the 9 industrial sectors. These data are chosen solely because of their consistency of collection, quality and availability. Should more data become available we could broaden our analysis. See Black, Guy and McLellan (2003) for details on this aggregation procedure.

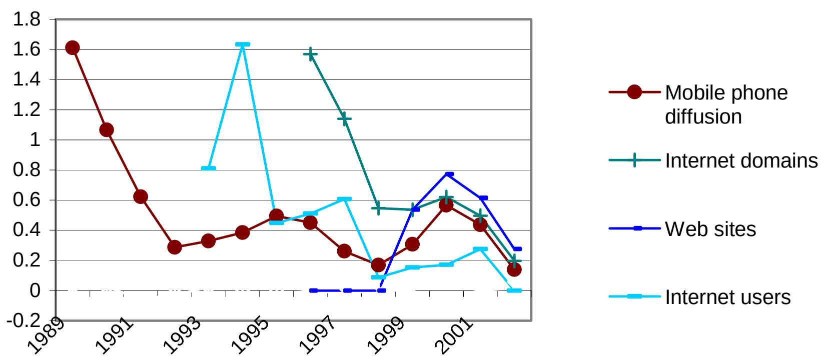
[9] The data are of an annual frequency with the observation taken for the month of June.

far as the available data reveals). Figure 3.2 shows several measures of ICT diffusion rates, which are all high around 1993.[10]

Table 3.2

Industrial Sector	Correlation Coefficient	t-stat.	Ave. TFP Growth Rate	Ave. IST Growth Rate
Primary	0.444755	0.600319	0.013061	0.02585
Mining and quarrying	-0.13522	-0.13445	0.004123	0.019507
Construction	0.545119	0.793985	-0.0184	0.02543
Manufacturing	0.364575	1.007994	-0.00354	0.027529
Electricity, gas and water	-0.09912	-0.2468	0.006498	0.030409
Transport and communications	0.169355	0.541571	0.05626	0.0455
Business and property services	0.091789	0.388129	-0.00964	0.07521
Personal and community services	0.017632	0.054999	0.015462	0.038775
Retail and wholesale trade	0.305878	0.915756	0.003513	0.040282

Figure 3.2: ICT diffusion rates in New Zealand



The diffusion of mobile phones was high from 1989 to 1992. The diffusion of the internet was highest in 1993-94 and the diffusion of other ICT technologies appears to have persisted at a high rate through to 2002.

The data produced by Statistics New Zealand also provide an opportunity to calculate a proximate measure for ICT diffusion rates and compare them to TFP growth rates in the 9 the industrial sectors. The data include measures of gross fixed capital formation of intangible assets which is a category that largely comprises computers and information technology related expenditures by industrial category at approximately the 1 digit ANZSIC level.

The rate of ICT diffusion appears to be uncorrelated or negatively correlated with the rate of TFP change in many industrial sectors. There is a significantly higher volatility in the diffusion rates relative to TFP change as well. After 1993, particularly in the industrial sectors of Business and Property Services, Personal and Community Services and Retail and Wholesale Trade, but through most of the industrial sectors the diffusion of ICT appears to become negatively correlated with TFP change. The time series of data is too short to statistically test sub-periods but this negative relationship between TFP growth and ICT diffusion is consistent with previous analysis of TFP and IST growth.

[10] The data on ICT diffusion comes from the New Zealand Ministry of Economic Development's report titled Statistics on Information Technology in New Zealand: Updated to 2003: URL http://www.med.govt.nz/pbt/infotech/it-stats/it-stats-2003/.

To see the degree of correlation between the two rates of change in each industry we again linearly regress TFP growth on ICT diffusion, noting again the flawed assumptions of a linear relationship between TFP growth and the rate of ICT diffusion. Using this technique again reveals that there is something wrong with TFP as a contemporaneous measure of technological change. Table 3.3 reports the correlation coefficients and *t* statistics for each sector.

Table 3.3

Industrial Sector	Correlation Coefficient	t-stat	Ave. TFP Growth Rate	Ave. ICT Diffusion Rate
Primary	-0.034	-0.892	0.013	0.127
Mining and Quarrying	0.046	1.348	0.004	-0.062
Construction	0.082	2.278	-0.018	0.100
Manufacturing	0.004	0.263	-0.004	0.036
Electricity, gas and water	-0.020	-1.160	0.006	0.106
Transport and communications	0.013	0.957	0.056	0.242
Business and property services	-0.010	-0.408	-0.010	0.078
Personal and community services	-0.001	-0.015	0.015	0.228
Retail and wholesale trade	0.025	1.114	0.004	0.054

The correlations are low in all cases and in some negative. However, none are significant. The high volatility of the ICT diffusion data and short time series of both sets of data preclude making any strong inference. The main conclusion to be drawn from this analysis is that more data is needed to be able to make conduct better statistical analysis.

The analysis of the New Zealand industrial sector data weakly supports the findings of the simulation model and the theoretical predictions of Carlaw and Lipsey (2003) and Lipsey a Carlaw (2004). TFP growth is not correlated with an independent measure of the technological change in the New Zealand economy. For the most part TFP growth and IST change are not significantly correlated.[11] Furthermore, based on available data it appears that New Zealand has been investing in ICT which has manifested in growth of IST at the same time that TFP growth has slowed.

4. CONCLUSION

This paper does two things. First, it adopts the Lipsey, Carlaw and Bekar (2005) and Carlaw and Lipsey (2001 and 2006) models of endogenous growth driven by GPTs in order to begin the development of a theory of TFP. The need for such a theory arrises out of the various, mutually incompatible, interpretations of TFP in the literature. Such a need also arrises out of the inconsistency in the interpretation of TFP growth as a measure of technological change when compared to other independent measures of technological change such as ICT diffusion (Carlaw 2004). The two different measures appear to be uncorrelated or even negatively correlated. Second, the paper utilizes two data sets to measure changes in investment quality which provide a direct measure of technological change that is independent of output growth.

In the adopted models, a sequence of GPTs arrive each at uncertain times and with uncertain productive impacts that diffuse according to a logistic process. The models assume behaviour that results in resource allocations such that a non-stationary equilibrium is generated. The model has the property that in the absence of future GPTs there are diminishing returns and growth asymptotically approaches zero. But the arrival of new GPTs rejuvenates the growth process.

Because this model requires a numerical solution procedure that is iterated through several periods it provides a ready opportunity for Monte Carlo analysis of the assumptions that

[11] These results are to be interpreted with caution since the time period consists of only 10 annual observations in each sector so that any interpretation of statistical significance is suspect.

underlay both endogenous growth modelling and TFP growth calculations. We do such and exercise here and confirm the arguments of Carlaw and Lipsey (2003) and Lipsey and Carlaw (2004) that TFP is not a measure of technological change. We find that while under some conditions TFP is positively correlated with direct and independent measures of technological change it persistently under estimates such technological change. Under other conditions, such as structural adjustment to accommodate a new GPT, TFP growth is negatively correlated with measured technological change and persistently underestimates technological change when a new GPT arrives and overestimates technological change as the GPT matures. In both models, TFP fails to detect the arrival of GPTs appropriately (i.e., as big technological shocks).

The findings in the IST empirical analysis are weak but consistent with the view that ICT is a major new transforming GPT that generates the kind of structural adjustment costs discussed in Lipsey, Bekar and Carlaw (1998b) and Lipsey, Carlaw and Bekar (forthcoming). In ten of the sixteen OECD economies examined TFP showed a negative correlation in a number of cases this correlation was significant. In the New Zealand industrial sector data none of the correlations are significant and two are negative. The interpretation of the sign and significance of the industrial sector data is limited by the small sample of only ten time serries observations.

These empirical findings have to be viewed with a critical eye because there are a number of assumptions necessary to interpret the measures of technological change as being valid. However, they do have the property that they are independent measures of technological change and therefore provide some basis of comparison and testing of the various interpretations of TFP growth. They also point in a common direction. TFP does not measure technological change. Furthermore, it may be negatively correlated with technological change when that change is driven by a transforming GPT such as ICT, which is something that the theory predicts.

What is obvious from the analysis is that more data are necessary to develop a theory of TFP further. A longer time serries of industrial level data would allow for more confident interpretation of the correlation estimates between IST and TFP change. This would also help to identify the characteristics of industrial sectors with respect to emerging general purpose technologies being adopted.

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