DRAFT

PRODUCTIVITY GROWTH: THE EFFECT OF MARKET REGULATIONS

Christopher Kent, John Simon and Kathryn Smith

April 2006

Economic Group

Reserve Bank of Australia

The views in this paper are those of the authors and do not necessarily reflect those of the Reserve Bank of Australia. We would like to thank the Overseas Economies section of Economic Analysis Department, the Reserve Bank of Australia, for help with compiling the data for this paper.

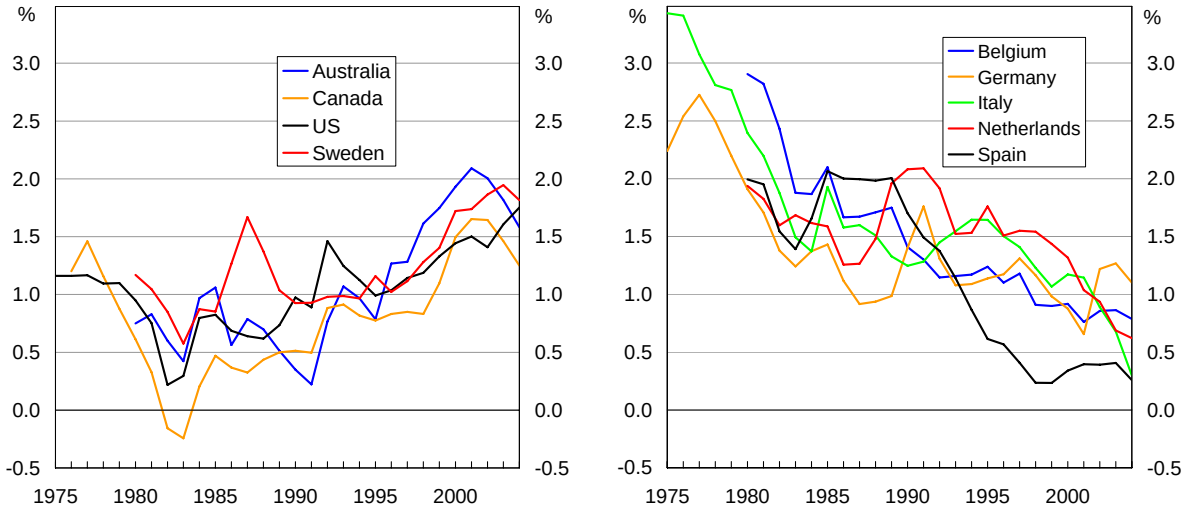
PRODUCTIVITY GROWTH: THE EFFECT OF MARKET REGULATIONS

Christopher Kent, John Simon and Kathryn Smith

1. Introduction

During the late 1990s it was fashionable to talk about the productivity revolution that information technology built. Despite the attention it received, the productivity revolution was relatively limited in geographical scope. A small group of OECD countries (including Australia, Canada, Sweden and the US) experienced a sizeable step up in their productivity growth in the 1990s (Figure 1).[1] For these countries, average total factor productivity (TFP) growth within the business sector rose by between 0.5 and 1.7 percentage points compared with the previous decade. However, at the same time, TFP growth rates declined across much of Europe.

Figure 1: TFP – Business Sector
Rolling 10-year average annual growth

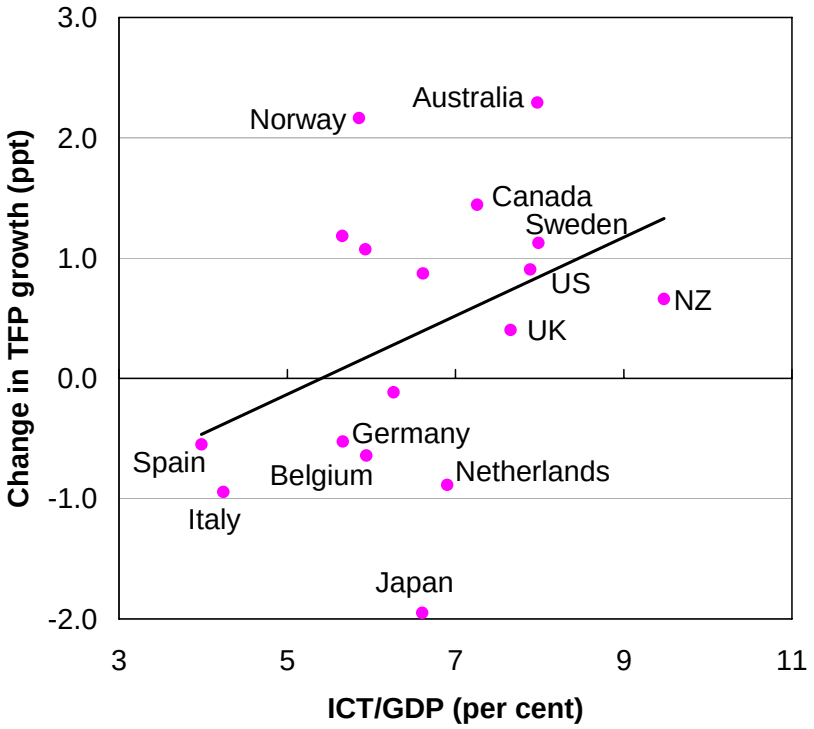


[1] In this paper the focus is on 18 OECD countries for which relevant data are readily available. These are: Australia, Belgium, Canada, Denmark, Finland, France, Germany, Ireland, Italy, Japan, the Netherlands, New Zealand, Norway, Spain, Sweden, Switzerland, the United Kingdom and the United States. For a description of data and sources, see Sections 3, 4 and the Appendix.

Explanations for the productivity surge have focused on the effect of production of or investment in information and communications technology (ICT). An influential paper by Oliner and Sichel (2000) attributed around two thirds of the step-up in (labour) productivity growth in the US over the 1990s to the use or production of ICT. In Australia, Simon and Wardrop (2002) estimated that IT-related capital deepening added over 1 per cent per annum to output growth in the 1990s or about one third of the step-up in labour productivity growth over the period. Looking across a wider set of OECD countries, there is clearly a positive correlation between expenditure on ICT (relative to GDP) over the 1990s and the change in TFP growth from the late 1980s to the late 1990s (Figure 2). Importantly, the Australian experience demonstrates that it was not necessary to produce ICT, as had been thought, in order to reap some of its productivity benefits. Unlike the United States and most of the other 'high tech' countries, Australia had no significant IT production.

Figure 2: ICT Spending Versus Change in TFP Growth

ICT – 1990s average, TFP – 1990 to 2000, 5-year-ended average

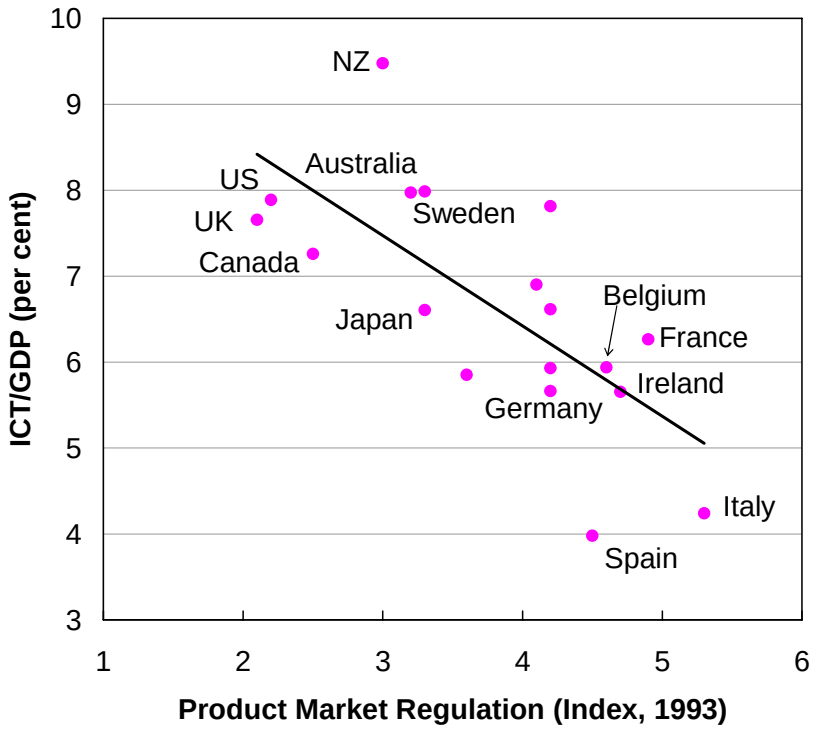


But if differences in ICT investment have caused recent differences in TFP growth, these papers leave a critical question unanswered. What led some countries to invest so heavily in ICT while others did not? One answer that has been suggested

is that those countries that did not invest heavily in ICT were hamstrung by rigid regulation of their labour and product markets. For example, Figure 3 shows that countries with higher levels of product market regulation in the early 1990s tended to have lower levels of ICT investment over the 1990s. Consistent with this, Gust and Marquez (2004) propose a model of productivity growth where labour and product market regulation explain ICT investment which, in turn, explains higher growth in labour productivity.

Figure 3: ICT Spending Versus Product Market Regulation

ICT – 1990s average, PMR – 1993



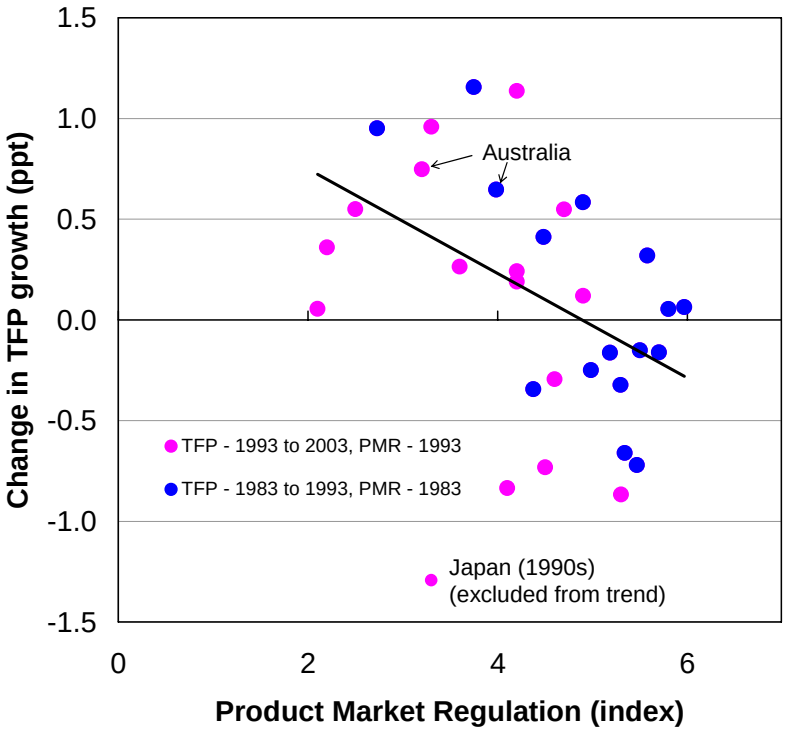
Note: PMR is an index ranging from 0 (least) to 6 (most) restrictive.

This 'two-step' approach – from regulation to ICT investment to productivity – ignores the potential *direct* link between reforms in product and labour markets and productivity growth. Ignoring this direct link has two potential shortcomings. The first is that market flexibility might accelerate TFP growth regardless of whether a country has invested heavily in ICT or not. Nicoletti and Scarpetta (2003 and 2005a) and Scarpetta and Tressel (2002 and 2004) argue that more flexible labour and product markets are critical for more rapid reorganisation of productive resources, thereby allowing countries to move towards the production frontier with greater speed. We argue that, in addition, the *interaction* of product

and labour market flexibility might also be important for TFP growth. Ignoring the possibility that labour and product market regulation directly affect TFP growth also precludes an investigation of this possible interaction.

A second shortcoming of ignoring possible direct effects of regulation is that changes in TFP growth have been apparent as part of a longer term trend that predates the 1990s 'tech boom'. As shown in Figure 1, the pattern of rising TFP growth in some countries but falling TFP growth in others has been evident in rolling 10 year averages of annual MFP growth for periods ending around the early 1980s onwards. Evidence in support of a direct link between flexible markets and TFP growth is provided in Figure 4. This shows data for the change in annual average TFP growth (on a 10-year ended basis) versus the initial degree of product market regulation over two different time periods (the ten years to 1993, and ten years to 2003). Countries which started each episode with less market regulation tended to experience higher TFP growth in the subsequent 10 years (compared with the 10 years prior). The trend shown (which covers all observations other than Japan for the 1990s episode) suggests that a single index point reduction in the regulations index is associated with a rise in annual average TFP growth of about 0.25 percentage points.

Figure 4: Change in TFP Growth and Product Market Regulation



This paper attempts to address both of the above shortcomings in two ways. First, we use data spanning the past thirty years to investigate the direct effects of product and labour market regulation on TFP growth. We find tentative support for the hypothesis that lower levels of regulations initially are associated with higher TFP growth over the following five to ten years, and that labour and product market deregulation have more of an effect in combination. Second, we investigate the relationship between TFP growth, ICT spending and product and labour market regulations using annual data from 1993-2004. Our regressions are specified so that regulations can affect productivity in three ways: directly, indirectly through ICT, and in combination through the interaction of product and labour market reforms. Using these annual data, we find little evidence that product and labour market regulations affect TFP growth, but this finding may merely reflect the fact that the effects of institutional changes on productivity growth are delayed and gradual.

The rest of the paper is structured as follows. Section 2 provides a brief review of the literature, noting the ways in which the paper extends the existing line of research. Section 3 discusses the data and methodological issues and presents results based on data over the past three decades. Results for the past ten years or so, for which data on ICT expenditure is readily available, are presented in Section 4. Section 5 concludes.

2. Literature Review

Investigations of the reasons for divergent growth between countries have been around since the *Wealth of Nations*. More recent investigations have been motivated by the phenomenon of 'eurosclerosis' (for example, Bean and Dreze 1990, Bruno and Sachs 1985, and Blanchard 1997). Dreze and Bean (1990) found, for example, that the effect of unemployment on wage settlements in Europe is generally weak and that productivity gains were quickly absorbed in higher wages. Blanchard found that European countries responded to labour shocks in very different ways than Anglo-Saxon countries, and that this difference led to generally higher unemployment in Europe. The common explanation for these different behaviours was differences in labour market institutions. However, while the role

of institutions was thought to be qualitatively well understood, these earlier papers did not directly quantify the role of institutions.

More recent papers have directly addressed the influence of institutions on macroeconomic variables including productivity. In particular, papers such as those by Blanchard and Wolfers (1999); Nicoletti and Scarpetta (2003); and Nicoletti *et al* (2001) have constructed indices of product or labour market regulation and applied them to explaining the phenomenon of low European growth. In general they find that institutions can have a deleterious effect on unemployment and productivity. Blanchard and Wolfers suggest that rigid institutions can entrench the effect of negative shocks. Nicoletti and Scarpetta examine panel data across countries and across industries and show that their index of product market regulation has significant explanatory power for TFP growth. They argue that the ability of firms to innovate, adopt new technologies and reorganise productive processes depends on the extent of restrictive regulations in labour and product markets, and present evidence that countries with fewer regulations move toward the technological frontier more quickly. However, they make use of variation in the extent and speed of reforms in only a limited way (ignoring, for example, significant changes in labour market reforms over time), nor do they allow for the possibility that reforms matter for aggregate productivity growth via a reorganisation of productive activities across different industries.

Another recent observation is that productivity growth and investment in ICT has been much higher in certain countries than in others.[2] By and large, this literature did not extensively consider the question of why some countries had invested heavily in ICT while others had not. Given these differences in ICT investment, some recent papers drawn on the literature about institutions and considered whether some countries' ICT use was constrained by product or labour market regulations. Gust and Marquez (2004) and Scarpetta and Tressel (2002, 2004) argue that the nature of ICT is such that the greatest gains are obtained by simultaneously reorganising business processes. As such, a necessary concomitant of successful ICT investment is business reorganisation. And rigid institutions can

---

[2] See, for example, Oliner and Sichel (2000) for the US; Simon and Wardrop (2002) and Parham *et al* (2001) for Australia; Colecchia and Schereyer (2001) for a range of OECD countries and Timmer and van Ark (2005) for the US and a range of European Union countries.

hinder this. Thus, the picture is that ICT investment acts as a catalyst for productivity growth in the presence of flexible market institutions.

This paper adds to the literature exploring the link between productivity growth and labour and product market institutions. In that respect, it explores similar questions to those posed by Nicoletti and Scarpetta (2003), Scarpetta and Tressel (2002 and 2004) and Gust and Marquez (2004). It extends these analyses in a number of respects.

Firstly, we use data pre-dating the 'tech boom' to examine the direct effects of product and labour market flexibility on TFP growth, both independently and in combination. The idea here is that while reforms that are limited to (say) product markets may enhance competitive pressures and encourage innovation, but without flexible labour markets, the ability of firms to restructure may be impaired, and the entry of new firms impeded. Similarly, labour market reforms may be less potent in the face of limited product market reforms, which would potentially impede innovation, reorganisation and new entrants.

Secondly, the paper examines the roles of both market regulations and ICT expenditure in explaining TFP growth over the 1990s. Unlike previous work, we allow product and labour market regulations to affect productivity growth directly, indirectly through ICT, and in combination through the interaction of product and labour market reforms.

Finally, the paper focuses on aggregate TFP growth. Studies that focus on industry level data may miss two potential impacts of regulatory reforms. First, reforms may encourage reallocation of resources across industries in a way that encourages aggregate productivity growth. Second, and perhaps less obviously, reforms that free up labour in some industries and help to spur productivity in others can have important spill-over effects for all industries by reducing the costs of business inputs, thereby lowering costs for new entrants.

3. Longer-term Results – the Past 30 Years

3.1 Data and Method

This paper uses fixed effects panel data regressions with growth in total factor productivity (TFP) as the dependent variable. Our first set of regressions examines the effects of product and labour market regulation on TFP growth in 16 OECD countries from 1974 to 2003.[3] Our second set of regressions, which includes ICT among the explanatory variables, is discussed in Section 4. The appendix provides detailed descriptions of our data and its sources while Table 1 summarises the key data.

We run the first regression with observations over three ten-year blocks. While the data are annual[4], estimating the regression over ten-year periods lets us better capture any relationship between TFP growth, which is quite volatile from one year to the next, and changes in the structure of product and labour markets, which are likely to have a delayed and more gradual impact on TFP growth. This is also consistent with the limited availability of the product market regulation variable (generally only every 5 years) and is one way to attempt to control for any influence of the business cycle on measured TFP growth (see below).

The dependent variable in our regressions is growth in TFP in the business sector. We calculate TFP from OECD data rather than directly from national data sources to increase cross-country comparability. Restricting our analysis to the business sector avoids the problems of measuring output and productivity in the government sector, and using an hours-based measure of labour inputs avoids the well-known problems with time series comparisons of heads-based productivity estimates. An important difference between our measure of TFP and some others is our measure of labour's share of income (LSI): we include an approximation of labour's share of gross mixed income (GMI) in our estimate of LSI.[5]

---

3 As discussed below, we exclude observations for the Netherlands and Japan in the 1990s from most of the regression analysis.

4 We geometrically interpolate the index of product market regulation to create an annual series; see below.

5 Specifically, we assume that all self-employed are paid average wages. The conceptually correct method for calculating LSI is to sum compensation of employees (COE), labour's

Table 1: Summary of Key Data

5-year averages

	TFP growth [1]			ICT spending [2]		PMR [3]			Days lost to labour disputes [4]		
	1993	1998	2003	1998	2003	1993	1998	2002	1993	1998	2003
Australia	0.95	2.28	1.35	8.1	7.2	3.2	1.9	1.5	137.3	78.1	39.0
Belgium	0.75	1.07	0.65	5.9	6.1	4.6	3.4	2.3	27.4	23.2	21.0
Canada	0.27	1.39	1.53	7.4	6.5	2.5	2.1	1.8	159.7	225.9	151.0
Denmark	0.71	1.74	0.14	6.6	6.4	4.2	3.0	1.7	31.6	416.4	37.7
Finland	0.82	4.04	2.01	5.9	7.1	4.2	2.7	2.5	78.9	39.2	28.5
France	0.51	0.81	1.04	6.2	6.5	4.9	4.3	3.3	37.6	44.1	73.8
Germany	0.75	1.58	0.95	5.5	6.1	4.2	2.8	1.7	16.6	1.5	4.3
Ireland	4.11	5.70	3.43	5.7	5.1	4.7	4.4	3.3	94.7	54.1	32.8
Italy	1.04	1.41	-0.06	4.2	4.6	5.3	4.7	2.7	146.5	61.5	121.0
Japan	1.29	0.41	0.41	6.4	7.8	3.3	2.9	2.3	2.3	1.3	0.3
Netherlands	1.62	1.46	-0.09	6.8	7.0	4.1	2.9	1.7	11.0	2.4	21.5
Norway	2.88	2.88	1.75	5.8	5.6	3.6	3.2	2.5	66.8	129.5	22.2
NZ	0.55	0.96	1.29	8.8	11.1	3.0	2.0	2.1	51.7	20.1	21.8
Spain	0.03	0.44	0.38	3.9	4.1	4.5	3.5	2.2	338.5	118.1	157.4
Sweden	0.19	2.36	1.52	7.9	7.9	3.3	2.4	2.0	19.8	7.3	50.4
Switzerland	--	0.97	0.21	7.6	8.0	4.2	3.7	2.9	0.1	2.7	3.8
UK	0.92	1.39	1.19	7.6	7.8	2.1	1.4	1.1	25.2	23.1	28.0
US	1.09	1.28	1.93	7.7	8.7	2.2	1.6	1.4	35.2	37.4	14.3
Average	**1.1**	**1.8**	**1.1**	**6.6**	**6.9**	**3.8**	**2.9**	**2.2**	**71.2**	**71.4**	**46.0**

10-year averages

	TFP growth [1]			TFP Gap [3]			PMR [4]			Days lost to labour disputes [5]		
	1983	1993	2003	1973	1983	1993	1978	1983	1993	1973	1983	1993
Australia	0.42	1.07	1.82	-31.9	-30.1	-32.3	4.0	4.0	3.2	450.8	413.0	137.3
Belgium	1.88	1.16	0.86	-34.2	-17.5	-21.1	5.5	5.5	4.6	216.9	56.8	27.4
Canada	-0.24	0.91	1.46	-3.1	-7.6	-12.9	4.0	3.7	2.5	570.9	563.4	159.7
Denmark	0.85	0.70	0.94	-39.5	-33.0	-40.1	5.5	5.5	4.2	550.4	114.4	31.6
Finland	2.10	1.89	3.02	-63.9	-53.6	-51.4	5.4	5.3	4.2	888.8	223.7	78.9
France	0.74	0.80	0.92	-4.2	-0.8	-5.9	6.0	6.0	4.9	189.7	87.5	37.6
Germany	1.24	1.08	1.27	-28.6	-19.5	-23.5	5.2	5.2	4.2	67.4	1.5	16.6
Ireland	3.70	4.02	4.56	-80.9	-51.1	-25.0	5.7	5.6	4.7	213.4	341.0	94.7
Italy	1.49	1.55	0.68	-24.8	-17.1	-19.0	5.8	5.8	5.3	1001.9	699.3	146.5
Japan	1.12	1.70	0.41	-38.9	-38.0	-35.4	5.1	4.9	3.3	101.9	9.4	2.3
Netherlands	1.68	1.52	0.69	-22.2	-9.2	-8.2	5.7	5.7	4.1	45.9	20.2	11.0
Norway	2.46	2.05	2.31	-22.0	-6.8	0.0	5.5	5.3	3.6	6.6	54.1	66.8
NZ	--	--	1.12	--	--	-36.1	4.9	5.0	3.0	140.5	236.4	51.7
Spain	1.39	1.14	0.41	-24.9	-15.1	-16.8	5.0	5.0	4.5	67.0	359.2	338.5
Sweden	0.58	0.99	1.94	-33.6	-31.9	-37.1	4.5	4.5	3.3	74.4	19.6	19.8
Switzerland	--	--	0.59	--	--	-42.3	4.1	4.2	4.2	1.0	0.5	0.1
UK	1.58	1.24	1.29	-26.4	-14.6	-17.2	4.8	4.4	2.1	609.2	186.3	25.2
US	0.30	1.25	1.61	0.0	0.0	-1.5	3.7	2.7	2.2	419.3	144.2	35.2
Average	**1.3**	**1.4**	**1.4**	**-30.0**	**-21.6**	**-23.7**	**5.0**	**4.9**	**3.8**	**312.0**	**196.1**	**71.2**

Notes: 1. TFP growth over 5- and 10-year windows ending in years shown.
2. ICT spending relative to nominal GDP, 3-year ended average.
3. Difference between the log level of TFP in country *i* and that of the technological leader (multiplied by 100).
4. Averages of indicators on regulatory and market environment for seven energy and service industries, see Nicoletti et al (2001) and Nicoletti and Scarpetta (2005). Scale 0-6 from least to most restrictive.
5. Number of working days lost due to industrial disputes per 1000 employees. Three-year ended average.

Sources: See Appendix.

Our measure of product market regulation (PMR) is an OECD index, which provides an internationally comparable measure of the degree to which government policies inhibit competition. This index covers regulations related to

share of GMI and net taxes on labour. Of course, labour's share of GMI is positive, and net taxes on labour are also likely to be positive (and relatively small). Hence the standard technique of approximating LSI solely with COE yields LSI estimates that are biased downwards.

barriers to entry (including legal and administrative barriers to entrepreneurship), public ownership, market structure, vertical integration and price controls (for more details see the appendix; Nicoletti *et al* 2001; and Nicoletti and Scarpetta 2003 and 2005). The index ranges from most restrictive (6) to least restrictive (0). The index is available about every five years from 1978 to 2002; where necessary, we interpolate the index geometrically to create annual data.[6] This index can be thought of as a 'direct' measure of a country's economic structure, in the sense that it is directly related to a country's economic regime, rather than a being a consequence of that structure.

Ideally, we would also include a direct measure of labour market regulations (LMR) in the regressions; however, a useful measure that also provides an indication of the extent of reforms over time is not readily available.[7] Hence, we use a proxy based on the number of days lost in labour disputes.[8] While the annual data are quite volatile, a three-year moving average shows a trend decline across most countries, and this trend appears to be consistent with the variation in the extent of labour market reforms across countries. Because the approach to industrial relations reform has been quite different across countries, an outcome-based measure such as this may be better than a direct measure. For example,

---

6 We also estimated Equation (2) below using a step function interpolation of the PMR index. While the two regressions are broadly similar, the geometric interpolation yields smaller and more stable coefficients on aggregate investment than the step function interpolation.

7 Scarpetta and Tressel (2002) use an indicator of Employment Protection Legislation (from Nicoletti, Scarpetta and Boylaud 1999), though this is available only for 1990 and 1998. The Economic Freedom of the World (EFW) Index provides an overall measure of labour market regulations. While useful for cross-country comparisons, these types of indices tend to understate the degree of reform within countries over time. Indeed, for Australia, the EFW measure suggests that the labour market was more regulated in recent years compared with the early 1990s, despite the significant reform over this period (Dawkins 2000). This may reflect the fact that measures of this type are only able to capture a limited set of factors that determine how the labour market operates, and it tends to rely heavily on objective interpretations of the legal framework.

8 It is possible that there is a mechanical relationship between the days lost to labour disputes in one year and TFP growth in the next. Whether or not such a relationship exists depends on: (i) how the labour input of striking workers is measured in each country in our sample; and (if measured hours worked *do* fall as a result of industrial action) (ii) the extent to which this decrease in labour inputs results in a fall in output, TFP, or some combination of the two. Even if such a mechanical relationship does exist, its effect will be negligible for the regressions where our dependent variable is average TFP growth over ten- or five-year periods.

Wooden and Sloan (1998) show that while Australia and the UK adopted different approaches to labour market reform, they have resulted in very similar labour market outcomes.

Both the PMR and LMR variables enter our regressions in levels rather than changes. With this specification, the economic interpretation of a significant negative relationship between a regulatory variable and TFP growth is that deregulating the relevant market causes a *permanent* increase in the growth rate of TFP. Although we do find such significant econometric relationships, we would caution against this economic interpretation. This is because it may be difficult to distinguish between lower levels of regulation leading to higher *levels* or higher *growth rates* of TFP over our sample periods.

The 'catch-up' theory of TFP growth suggests that the further a country is from the technological frontier, the faster its subsequent TFP growth rate will be. Other things equal, countries further from the technological frontier could be expected to experience more rapid TFP growth as they adopt more advanced technologies and productive practices. It is also plausible that the rate of this convergence might depend on the degree of labour and/or product market flexibility. To capture these effects we consider a 'technological gap' as an explanatory variable in our regressions, and include interactive terms between the technological gap and the regulatory variables. The gap is the difference between the logged level of TFP in each country and the technological leader and its construction follows that of Scarpetta and Tressel (2002).

If changes in the quality of labour inputs are not taken into account, increases in the amount of human capital over time can be wrongly attributed to increases in TFP. We therefore include average years of schooling as a proxy for human capital in our regressions. Clearly the proxy is imperfect as it measures a process (education) rather than an outcome (human capital formation) and does not capture post-school human capital formation, but it has been found to be an adequate measure in other studies (Bassanini *et al* 2001).

Measured TFP growth may be influenced by the state of the business cycle, and business cycles are not perfectly synchronized across countries. It follows that international comparisons of productivity growth may be distorted unless one

controls for the business cycle in each country. This can be done either directly or indirectly. Direct control involves including an indicator of the cycle as an independent variable, while indirect control involves smoothing the dependent variable to remove its cyclical component. Skoczylas and Tissot's (2005) analysis of cross-country labour and multifactor productivity compares these methods of controlling for the cycle. While they favour the former, the authors note that, for most countries in their sample, the results of using each method are broadly similar. Our method for adjusting for the cycle could be considered a hybrid of the direct and indirect approaches. When using data over 10-year blocks, much of the effect of the cycle is controlled for indirectly. We also allow for the inclusion of an indicator of the cycle (an output gap) as an independent variable in the regressions. Our gap is the difference between the natural logarithms of actual and trend business sector output, where trend is constructed with an HP filter. The standard end-point problem is partially mitigated by including three years of OECD forecasts for business sector output when smoothing those series.[9]

In summary, we estimate regressions based on the following general formulation:[10]

$$\begin{aligned} dtfp_{it} = {} & \beta_1 PMR_{it-1} + \beta_2 LMR_{it-1} + \beta_3 PMR_{it-1} * LMR_{it-1} \\ & + \beta_4 tfpgap_{it-1} + \beta_5 tfpgap_{it-1} * LMR_{it-1} + \beta_6 tfpgap_{it-1} * PMR_{it-1} \\ & + \beta_7 tfpgap_{it-1} * LMR_{it-1} * PMR_{it-1} + \beta_8 outputgap_{it} + \beta_9 T + \alpha_i + \varepsilon_{it} \end{aligned} \quad (1)$$

where: $dtfp_{it}$ is average annual growth in TFP for country *i* over the period in question; PMR_{it-1} is the lagged level of the product market regulations index; LMR_{it-1} is the lagged level of working days lost to labour disputes (smoothed by taking averages over 3-year periods); $tfpgap_{it-1}$ is the level of the gap between TFP in country *i* and the leading country described above; $outputgap_{it}$ is the average annual value of the output gap over the period *t* (included in some versions of the regression); and *T* is a time trend included in some versions of the regressions. Time periods, *t*, covers three ten-year blocks, ending in 1983, 1993 and 2003. The regulation variables and TFP gap are measured on a period-ended basis, that is, the year just prior to the start of the ten-year block *t*; the exception to

---

9 We also estimated regressions below using output gaps from the OECD's Economic Outlook No.78 Database. There results were very similar.

10 This specification loosely follows that used, for example, by Scarpetta and Tressel (2002) who provide a more formal derivation of the specification from first principles.

this is for the first ten year period for which the PMR index is only available for 1978.

3.2 Results – 10-year Blocks

The first point to note is that regressions based on the full sample (results not reported) show that residuals for Japan and the Netherlands in the 10-year period ending in 2003 stand out as being particularly large.[11] This is because these countries experienced the 4th and 5th largest declines in PMR from 1983 to 1993 (after the UK, NZ and Norway), and yet both experienced among the largest declines in average TFP growth from the ten years ending 1993 to the ten years ending 2003. In what follows we exclude observations for the Japan and the Netherlands in the 1990s. The exclusion of outlying observations is fairly common in the literature, in part reflecting problems with errors in variables and omitted variables that may be especially relevant to some observations (see, for example, Nicoletti and Scarpetta 2003). For Japan, the after-effects of the financial bubble are likely to have played an important role. For the Netherlands, wage moderation enabled a very large rise in participation through the 1990s (without a commensurate increases in labour market flexibility), which was associated with a sharp decline in labour and total factor productivity (for a discussion of the Dutch case see Naastepad and Kleinknecht 2002 and Bell 2004).

The key results of estimating a number of variants of Equation (1) using OLS appear in Table 2 (these exclude observations for Japan and the Netherlands in the 1990s). Model 1 is a basic regression with only the PMR and LMR measures (and their interactive term) included. The coefficients on the LMR and interactive terms are significant by themselves. The coefficient on PMR is not – its p-value is only 0.16, but excluding it from the model leads to a large drop in the model's fit. The PMR variable is significant in the absence of the LMR and interactive terms (results not shown), and its coefficient is of a similar order of magnitude as per Model 1. Also, a similar specification to Model 1using data in 5-year blocks (Model 5) shows PMR to be significant in its own right, and with a coefficient of a similar order of magnitude to that of Model 1 (see below for further discussion).

[11] So too does that for Canada in the 1970s, but exclusion of this observation makes no substantial difference to the following results.

Table 2: Panel Regression Results for Growth in TFP - Equation (1)
Fixed-effects estimation, three 10-year blocks ending in 1983, 1993 and 2003

		Model				
Variables	**Lag**	**1**	**2**	**3**	**4**[(b)]	**5**[(c)]
PMR	t-1	-0.21	0.12		-0.32	-0.21**
LMR	t-1	-0.008***	-0.013***	-0.009***	-0.011**	-0.009***
PMR*LMR	t-1	0.0016***	0.0026***	0.0017***	0.0023**	0.0016***
Human capital	t-1		0.12		-0.21	
TFP gap	t-1		-0.090**	-0.085***	-0.037	
TFP gap*PMR	t-1		0.015**	0.015***	0.0061	
TFP gap*LMR	t-1		-0.00026		8.2×10^{-5}	
TFP gap*PMR*LMR	t-1		5.1×10^{-5}		2.5×10^{-5}	
Output gap	t				-0.17**	-0.20***
Number of observations		48	48	48	65	81
R^2 within [(a)]		0.33	0.54	0.47	0.38	0.29
p-value for rejecting F test of overall significance		0.02	0.0005	0.0007	0.0088	0.001

Notes: ***, ** and * indicate that coefficients are significant at the 1, 5 and 10 per cent significance levels, respectively, using robust standard errors. Models 2-5 exclude observations from 1994 to 2003 for Japan and the Netherlands. PMR – product market regulations, index from 6 (most restrictive) to 0 (least restrictive). LMR – labour market regulations, days lost to labour disputes per 1000 employees.

(a) The R^2 within does note take account of the explanatory power from the constant

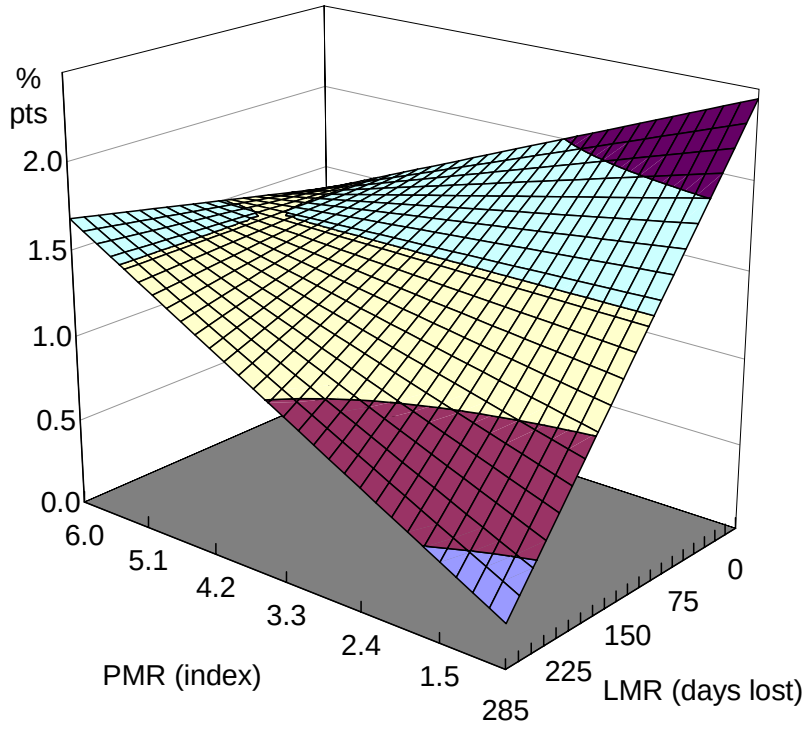
(b) Based on five 5-year blocks, ending in 1983, 1988, 1993 and 1998 (due to missing data for human capital).

(c) Based on five 5-year blocks, ending in 1983, 1988, 1993, 1998 and 2003.

Because of the interactive term, the interpretation of the marginal contributions of reforms in labour and product markets depends on the level of the other regulatory variable. This can be seen in Figure 5, where changes in the vertical height of the surface show the estimated changes in TFP growth for given changes in LMR and PMR. Over the sample period, most countries moved from points near the front and left of the surface (with PMR clustered around 5) to points on the rear and right of the surface (with PMR falling to around 2 in many cases and LMR values

clustered around 100 or less).[12] Within the regions of reform actually observed, the shape of the surface shows that deregulation in labour and product markets had larger effects when undertaken in combination.

Figure 5: Estimated Contribution to TFP Growth, Model 1



Model 2 is the more comprehensive specification, with human capital, the TFP gap and related interactive terms with the regulatory variables all included. The TFP gap by itself is significant and enters with a negative coefficient. This implies that the further a country is behind the lead country in terms of the level of TFP, the faster will be its average TFP growth over the next decade. PMR is not significant by itself, but it becomes significant when interacted with both LMR and the TFP gap variables. The coefficient on the interactive term between PMR and TFP gaps is positive, implying that the technological gap can be closed more quickly when product market regulations are less restrictive. Once again, the marginal impacts of deregulation in both labour and product markets are complex because of the presence of these interactive terms.

---

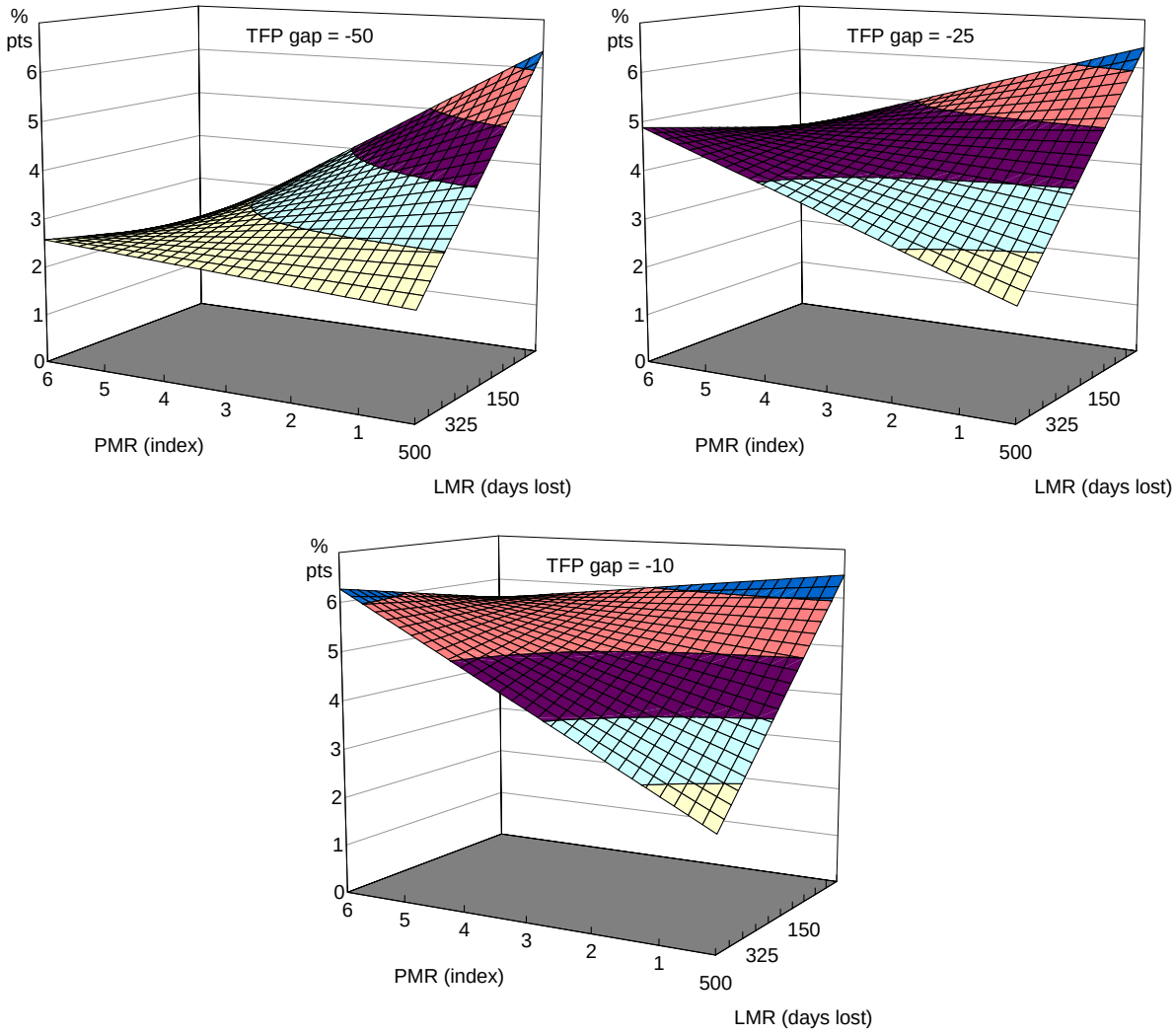
[12] The estimated marginal effect of labour market deregulation on TFP growth is positive for values of PMR below 5.3. The estimated marginal effect of product market deregulation is also positive for values of LMR below 130 (days lost per 1000 workers).

To interpret these interactions, we remove the insignificant variables from Model 2 to obtain the parsimonious Model 3. To illustrate the estimated contribution to TFP growth of changes in the regulatory environment we can examine a surface similar to that of Figure 5 for each of three different TFP gaps: large; intermediate; and small. These surfaces are shown in Figure 6. For all three TFP gaps, the contribution of labour market deregulation is positive so long as the product market is not too heavily regulated (a PMR index of less than about 5.6); it is also much larger at lower levels of product market regulation. The contribution of product market deregulation depends on the levels of both LMR and the technology gap. As in Figure 5 above, the contribution is actually negative at relatively high levels of labour market regulation. However, in our sample, countries deregulating product markets also tended to be deregulating labour markets, so this result should not be taken too literally. For moderate to low levels of labour market regulation, product market reforms are estimated to make a positive contribution to TFP growth. This contribution is larger the lower is labour market regulation, and the larger is the TFP gap.

These results are robust to attempts to control for the business cycle as per Equation (1) and to the exclusion of individual countries from the sample. They are also robust to the inclusion of either a time trend or time dummies (which were not themselves significant).

We also examined results based on using data in 5-year blocks (Models 4 and 5). This has the advantage of more degrees of freedom by greater use of the time dimension, but at the expense of a potential increase in measurement error. To account for the impact of the business cycle on measured TFP growth we included the output gap in regressions as per Equation (1) (the coefficient on this variable was -0.2 and statistically significant). The main difference between these and the 10-year block regressions is that the TFP gap and its interactive terms were no longer significant. The results for the parsimonious Model 5 is very much like that of Model 1 (based on 10-year blocks), though with PMR now significant in its own right. This was not the case in the presence of time trends or time dummies, though the time trend was not significant in the presence of the PMR variable and the inclusion of the trend added only marginally to the explanatory power of the model.

Figure 6: Estimated Contribution to TFP Growth, Model 3



4. The 1990s and the Role of ICT

4.1 Data and Method

Following Gust and Marquez, we now examine the significance of product and labour market regulation in the presence of ICT spending. Gust and Marquez examine the relationship between institutions and ICT, but data limitations restrict their analysis to the indirect role of product and labour market institutions. These limitations constrain Gust and Marquez to estimate the relationship between productivity, ICT spending and institutions using two equations. The first shows evidence of a statistically significant, positive relationship between ICT spending

and labour productivity growth.[13] The second shows that indices of labour and general regulations are jointly significant and have a depressing effect on ICT spending.[14]

With our measures of regulation and a longer sample period we are able to allow for the possibility of a direct link between labour and product market regulations and TFP growth. The specification is as per Equation (1) but with annual data, and two additional terms: ict_{it-1}, which is the first lag of ICT expenditure as a share of GDP; and inv_{it-2}, which is the second lag of business investment as a share of business sector output. Data are annual from 1993 to 2004.[15] The measure of human capital is not included due to a lack of annual observations over the sample.

Our measure of ICT use is the ratio of spending on ICT to GDP, as in Gust and Marquez (2004), which includes spending on IT (hardware, software and services) and telecommunications (equipment and services).[16]

Firms' general capital spending (the ratio of business sector gross fixed capital formation to business sector output) is included to test whether there is something 'special' about the way that ICT capital affects TFP growth. We use the second lag of the investment measure in our regressions to account for the delay between firms' purchasing and using capital goods and to avoid the mechanical link between investment and TFP growth. Theoretically, TFP growth will be mechanically linked to the first lag of ICT investment. However, ICT forms a relatively small proportion of most countries' business sector capital stocks, so

---

13 This relationship is not robust to the inclusion of an output gap or aggregate investment as explanatory variables.

14 The first equation is a fixed-effects panel data regression with growth in labour productivity as the dependent variable and the ratios of ICT production and spending to GDP as explanatory variables. Because of insufficient observations for the labour market regulation variable, the second equation is estimated with pooled data for 13 countries over the period 1992-1999. The dependent variable is ICT expenditure as a share of GDP and the levels of labour market and general regulations appear among the explanatory variables.

15 In these regressions we use the first lag of the output gap. The contemporaneous gap is highly correlated with the TFP growth when the latter is observed annually and the relationship between the two variables is likely to be mechanical.

16 To our knowledge this is only dataset that covers all of the countries in our sample. Timmer and van Ark (2005) discuss some of the problems with these data and construct an improved measure of ICT investment for the US and some European Union countries. Despite the levels differences between these two series, countries' rankings seem to be fairly similar.

using the first lag of ICT spending ought to capture a causal, non-mechanical relationship between TFP and investment in ICT.

4.2 Results

The regression results appear as Model 6 in Table 3. ICT spending has a significant and sizeable positive effect on TFP growth. This is in addition to the positive effect of aggregate investment on TFP growth. The PMR, LMR and interactive variables are not statistically significant.

Another way to examine the effect of regulations on TFP growth is to run the same regression but with the ICT variable interacted with dummy variables which distinguish between three different groups of countries according to their level of regulations. We divide countries into three groups of 'low', 'middle' and 'high' regulation countries according to their average levels of both PMR and LMR at the start of the sample period.[17] Results are shown as Model 7. Wald tests show there is no statistically significant difference between the effect of ICT spending on TFP growth in low and high regulation groups.

The positive coefficient on PMR may seem odd at first. Because of the use of annual data, the regression does not appear to have captured the delayed and gradual effects of structural reform on TFP that are likely to play out over longer horizons. Instead, the results reflect what appears to be the apparent convergence in product market regulation across countries that occurred over the 1990s. That is, countries with more regulated product markets in 1993 tended to have had larger subsequent reductions in regulation (Figure 7).[18] Section 3 showed that low starting levels of PMR are associated with higher TFP growth over the longer term. It makes sense, therefore, that larger declines in PMR from one year to the next over the 1990s (that is, high initial PMR) were associated with relatively weak TFP growth (as indicated by the positive coefficient on PMR in model 7). Neither of

---

[17] For labour market regulations we use the EFW index of labour market regulations (average value for 1990 and 1995). Countries with 'low' regulations (Australia, Canada, Norway, UK, US) are those with below average PMR and LMR values, countries with 'high' regulations (Belgium, Finland, France, Germany, Italy, Spain) are those with above average values, and all others (Denmark, Ireland, NZ, Sweden, Switzerland) are considered 'middle' ranking countries; Japan and the Netherlands are excluded as mentioned above.

[18] This pattern of regulatory convergence is also evident over the period from 1998 to 2002.

these two models is particularly robust to the inclusion of time dummies or a time trend. In particular, ICT spending is no longer significant once time dummies are included in either model.

Figure 7: Product Market Regulation Convergence

1993 to 2002

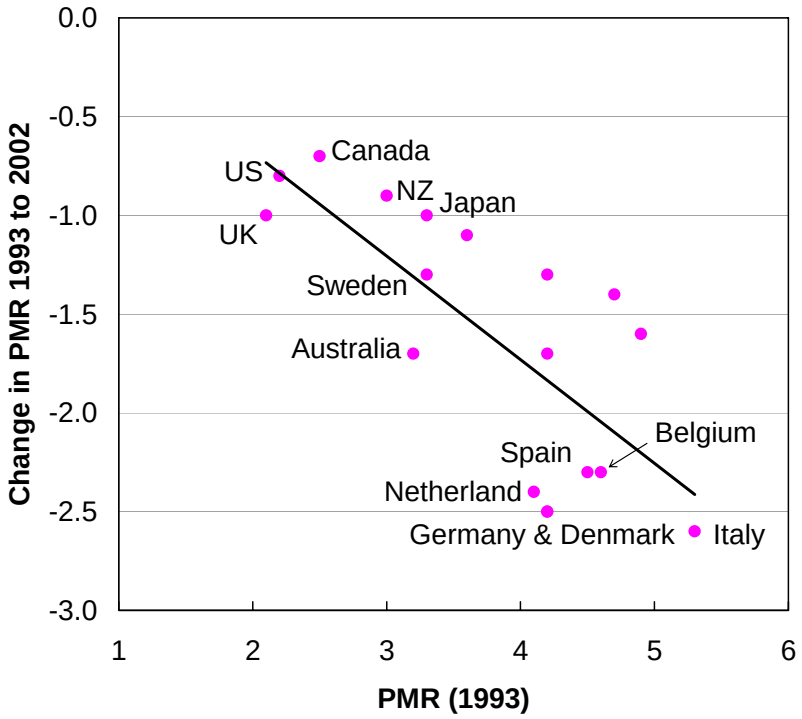


Table 3: Panel Regression Results for Growth in TFP - Equation (2)
Fixed-effects estimation, annual data 1993-2004

		Model	
Variables	**Lag**	**6**	**7**
ICT spending	t-1	0.30**	
ICT*Low regulation dummy	t-1		0.38**
ICT*Middle regulation dummy	t-1		0.18
ICT*High regulation dummy	t-1		0.66**
Investment	t-2	0.22***	0.21***
PMR	t-1	0.27	0.46*
LMR	t-1	-0.009	0.0005
PMR*LMR	t-1	0.004	-0.0003
TFP gap		0.017	-0.0010
TFP gap*PMR		-0.009	
TFP gap*LMR		-0.0005	
TFP gap*PMR*LMR		0.0002	
Output gap	t-1	-0.38***	-0.36***
Number of observations		192	192
R^2 within [(b)]		0.42	0.40
p-value for rejecting F test of overall significance		0.000	0.000

Notes: ***, ** and * indicate that coefficients are significant at the 1, 5 and 10 per cent significance levels, respectively, using robust standard errors. Models exclude observations for Japan and the Netherlands. PMR – product market regulations, index from 6 (most restrictive) to 0 (least restrictive). LMR – labour market regulations, days lost to labour disputes per 1000 employees.

(a) Models 7 uses dummies that group countries according to their PMR and LMR values. Average PMR and LMR are both below average in 'low' regulation countries, above average in 'high' regulation countries. All others fall into the 'middle' category.

(b) The R^2 within does note take account of the explanatory power from the constant.

5. Conclusion

This paper has extended the existing literature on institutions and productivity in a number of ways. When examining the roles of market regulations and expenditure on information and communications technologies in explaining TFP growth over the 1990s, we allowed for product and labour market regulations to affect productivity growth directly, indirectly through ICT, and in combination through the interaction of product and labour market reforms. However, clearly establishing a link between ICT and market flexibility is difficult in this period. We suggest that the difficulty might lie in part with the likelihood that the effect of deregulation (on both ICT expenditure and TFP growth) is delayed and gradual. For data spanning the 1990s, this difficulty is compounded by an apparent convergence in product market regulation, whereby countries with higher initial levels of regulation tended to catch up to the others. So, it may not be so surprising that those countries experiencing the greatest gains in moving towards more flexible markets also experienced the weakest TFP growth over the 1990s, as they also started with the least flexible markets.

The paper also explored the effects of product and labour market regulations of TFP using a longer sample covering the past three decades or so, again investigating the effects of interacting regulatory variables. We find evidence that lower levels of regulation are associated with higher TFP growth over subsequent years. There is some evidence that labour and product market deregulation have more of an effect in combination. That is, greater flexibility in one dimension appears to be more beneficial when the other market is also relatively flexible. It also appears that product market deregulation has a larger positive effect on productivity growth the further a country is from the production (or technological) frontier.

Appendix: Data Description and Sources

TFP growth. Growth (calendar year on calendar year) in total factor productivity in the business sector. Total factor productivity is constructed by dividing real business sector GDP by a Tornqvist index of labour and capital inputs. The labour input is aggregate hours worked, which is the product of business sector employment and average hours per employee. The capital measure is the real business sector capital stock. The labour share of income is estimated by adding an approximation of labour's share of gross mixed income to compensation of employees:

$$LSI_{it} = \frac{[CoE_{it} + SE_{it}(CoE_{it}/(E_{it} - SE_{it}))]}{GDP_{it}} \qquad \text{(A1)}$$

where LSI_{it} is labour's share of income in country *i* at time *t*; CoE_{it} is compensation of employees; SE_{it} is the number of self-employed people; E_{it} is total employment and GDP_{it} is aggregate nominal GDP. We approximate average compensation of employees with $CoE_{it}/(E_{it} - SE_{it})$ as the numbers of wage and salary earners is not available for all countries over a long enough time period. All the data are annual and are sourced from the OECD Economic Outlook Database No.78. Exceptions are estimates of New Zealand business sector employment, which are quarterly data from the OECD Economic Outlook Database No.77, and components of labour's share of income, which are annual OECD data sourced from Thomson Financial.

Product market regulations. Originally from Nicoletti *et al* (2001); we use the updated version presented in Nicoletti and Scarpetta (2005). Countries are classified on a 0-6 scale from least to most restrictive for each regulatory and market feature of each industry: airlines, railways, road, gas, electricity, post and telecommunications. Dependent on the industry, the features covered are: barriers to entry, public ownership, market structure, vertical integration and price controls. Aggregate indicators for each country are simple averages of indicators for the seven industries. These data are separate to the commonly cited economy-wide indicators, which are only available for 1998 and 2003 (Nicoletti *et al* 1999; Conway, Janod and Nicoletti 2005). Nicoletti and Scarpetta (2003) suggest that

reforms in the seven industries are representative of economy-wide regulations. Data are geometrically interpolated to create an annual series.

Working days lost to labour disputes per thousand employed. Constructed from the number of working days lost (from the International Labour Organisation) and the level of employment. The exceptions are: Australia – OCED Main Economic Indicators (MEI); Belgium – Eurostat; Canada – MEI; France. Eurostat; Germany – data from 1993 from Eurostat; Netherlands – Eurostat; US – MEI. Employment data from OECD Economic Outlook, sourced from Datastream. Data are smoothed using a backward-looking three-year moving average.

Technology gap. The gap is estimated as follows:

$$tfpgap_{it} = 100[\ln(TFP_{it}) - \ln(TFP_{Lt})] \tag{A2}$$

where $tfpgap_{it}$ is the technology gap for country *i* at time *t*, and TFP_{it} and TFP_{Lt} are the levels of TFP in country *i* and the technological leader at time *t*. The level of TFP is given by the index

$$TFP_{it} = \frac{Y_{it}}{\overline{Y_t}} \left(\frac{\overline{L_{it}}}{L_t} \right)^{\sigma_{it}} \left(\frac{\overline{K_{it}}}{K_t} \right)^{1-\sigma it} \tag{A3}$$

where TFP_{it} is the level of TFP in country *i* at time *t*; Y_{it} is the level of real output in the business sector; K_{it} is the level of the real business sector capital stock; and L_{it} is the level of aggregate hours worked in the business sector. Variables with a bar are geometric means for all countries at time *t* and σ_{it} is given by

$$\sigma_{it} = \frac{1}{2}(\alpha_{it} + \overline{\alpha}_t) \tag{A4}$$

where α_{it} is the LSI for country *i* at time *t*. If the output and capital stock data have been appropriately converted to a common currency, levels of TFP constructed with this index are comparable across countries, so the TFP leader can be identified. As our real output and capital stock data are based in different years depending on the country, we first rebase these data to a common year (2000) and then convert to US dollars using 2000 purchasing power parity (PPP) exchange

rates. Output and the capital stock are rebased using implicit price deflators (IPD) for aggregate output and private non-residential investment from the OECD Economic Outlook No. 78. Rebased output is converted to US dollars using the 2000 PPPs over GDP from the OECD. The rebased capital stocks are converted to US dollars using 2000 PPPs over investment constructed by multiplying price indices for investment expenditure from Penn World Tables 6.1 by exchange rates from the OECD.

Average years of schooling. Geometric interpolation of the average years of schooling data constructed by de la Fuente and Domenech (2002). These data are a revised and partially extended version of the series in de la Fuente and Domenech (2000). Average years of schooling are observed every five years from 1960-1995, with the exception of France, Japan, Spain and the UK, for which there is no observation for 1995. We construct these observations by assuming that average years of schooling grew at their 1985-90 rates over 1990-95.

ICT expenditure. Total nominal expenditure on information technology (IT) (hardware, software and services) and telecommunications (equipment and services) as a percentage of aggregate nominal GDP. Source: World Information Technology Service Alliance (2000, 2002 and 2004).

Investment share of GDP. Gross Fixed Capital Formation in the business sector as a percentage of business sector GDP, constructed from the OECD Economic Outlook No.78 Database.

Output gap. Difference between natural logarithms of actual and trend business sector output, where trend business sector output is real business sector GDP from the OECD Economic Outlook No.78 Database, smoothed with a Hodrick Prescott filter using a smoothing parameter of 100. When smoothing we included the forecasts for real business sector output for the years 2005-2007; these forecasts are published in OECD Economic Outlook No.78 Database.

References

Bassanini, A, S Scarpetta and P Hemmings (2001), 'Economic Growth: the Role of Policies and Institutions. Panel Data Evidence from OECD Countries', OECD Economics Department Working Paper No. 283.

Bell G (2004), 'Recent Productivity Trends in the Netherlands', in IMF Country Report No. 04/301, pp 21–40.

Blanchard, O (1997), 'The Medium Run', *Brookings Papers on Economic Activity*, 2, pp 89-158.

Blanchard, O and J Wolfers (1999), 'The Role of Shocks and Institutions in the Rise of European Unemployment: the Aggregate Evidence', NBER Working Paper Series No. 7282.

Bruno, M and J Sachs (1985), *Economics of Worldwide Stagflation*, Blackwell, Oxford.

Colecchia, A and P Schreyer (2001), 'ICT investment and economic growth in the 1990s: is the United States a unique case? A comparative study of nine OECD countries', STI Working Paper No. 2001/7.

Conway P, V Janod and G Nicoletti (2005), .Product market regulation in OECD countries: 1998 to 2003, OECD Economics Department Working Paper No 419.

Dawkins P (2000), 'The Australian labour market in the 1990s', in D Gruen and S Shrestha (eds), The Australian economy in the 1990s, Proceedings of a Conference, Reserve Bank of Australia, Sydney, pp 316–352.

de la Fuente, A and R Domenech (2002), 'Educational Attainment in the OECD, 1960-95', Centre for Economic Policy Research Discussion Paper No. 3390.

de la Fuente, A and R Domenech (2000), 'Human Capital in Growth Regressions: How much Difference does Data Quality Make?', Centre for Economic Policy Research Discussion Paper No. 2466.

Dreze, J and C Bean (1990), 'European Unemployment: Lessons from a Multicountry Econometric Study', *Scandinavian Journal of Economics*, 92(2), pp 135–165

Gust, C and J Marquez (2004), 'International Comparisons of Productivity Growth: The Role of Information Technology and Regulatory Practices', *Labour Economics*, 11(1) pp 33–58.

Naastepad, C W M. and A Kleinknecht (2002), 'The Dutch Productivity Slowdown: The Culprit at Last?', mimeo, Delft University of technology.

Nicoletti G, A Bassanini, E Ernst, S Jean, P Santiago and P Swaim (2001), 'Product and labour markets interactions in OECD countries', OECD Economics Department Working Paper No 312.

Nicoletti, G, S Scarpetta and O Boylaud (1999), 'Summary indicators of product market regulation with an extension to employment protection legislation', OECD Economics Department Working Paper No. 226.

Nicoletti, G and S Scarpetta (2005), 'Product Market Reforms and Employment in OECD Countries', OECD Economics Department Working Papers No. 472.

Nicoletti, G and S Scarpetta (2005a), 'Regulation and Economic Performance: Product Market Reforms and Productivity in the OECD', OECD Economics Department Working Papers No. 460.

Nicoletti G and S Scarpetta (2003), 'Regulation, productivity and growth: OECD evidence', Economic Policy, 36, pp 11–72.

Oliner, S and D Sichel (2000), 'The Resurgence of Growth in the Late 1990s: Is Information Technology the Story?', *Journal of Economic Perspectives*, 14(4), pp 3–22.

Parham, D, P Roberts and H Sun (2001), *Information Technology and Australia's Productivity Surge*, Productivity Commission Staff Research Paper, AusInfo, Canberra.

Scarpetta, S and T Tressel (2004), 'Boosting Productivity via Innovation and Adoption of New Technologies: Any Role for Labor Market Institutions?', World Bank Policy Research Working Paper No. 3273.

Scarpetta, S and T Tressel (2002), 'Productivity and Convergence in a Panel of OECD Industries: Do Regulations and Institutions Matter?', OECD Economics Department Working Paper No. 342.

Simon, J and S Wardrop (2002), 'Australian Use of Information Technology and its Contribution to Growth', Reserve Bank of Australia RDP No. 2002-02.

Skoczylas, L and B Tissot (2005), 'Revisiting recent productivity developments across OECD countries', BIS Working Papers No. 182.

Timmer, M and B van Ark (2005), 'Does information and communication technology drive EU-US productivity growth differentials?', *Oxford Economic Papers*, 57, pp 693–716

Wooden M and J Sloan (1998), 'Industrial relations reform and labour market outcomes: a comparison of Australia, New Zealand and the United Kingdom', in G Debelle and J Borland (eds), *Unemployment and the Australian labour market*, Proceedings of a Conference, Reserve Bank of Australia, Sydney, pp 169–203.

World Information Technology Service Alliance (2000, 2002 and 2004), *Digital Planet 2000, etc*, World Information Technology Service Alliance, Arlington, Virginia.