evidence that the skills premium has widened in the United Kingdom (as it did earlier in the United States) is potentially consistent with this view. This hypothesis also suggests that, on its own, ICT might be an inadequate proxy to capture fully the complementary investments we think are happening.

In addition, although labor and product market regulation generally appear similar, differences in competitive intensity could still play a role. A major contrast between the United States and the United Kingdom is in wholesale and retail trade. As we have seen, productivity rose sharply in these industries in the United States after 1995, but it fell in the United Kingdom. Some (e.g., Lovegrove et al., 1998) have blamed restrictive planning laws in the United Kingdom, which may have hampered the growth of so called big box retailing.[46] But it is not immediately clear why the major U.K. retailers (who also perform the wholesale function) should invest less in ICT for this reason alone: why would a comparatively low store size in a chain of supermarkets inhibit the retail firm from investing in computerized inventory control systems? However, if planning laws reduce competitive intensity by blocking entry, then they may inhibit investment too. In any event, the role of competitive intensity also seems a fruitful topic for future research.

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46. This is the term used to label very large retailers, typically selling from windowless, rectangular buildings surrounded by parking lots.

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Comment

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This is a very ambitious, very careful, very honest paper. Unfortunately, ambition, care, and honesty are only necessary conditions for success. A bit of luck is also needed and, in this case, luck was not there. The case of U.K. missing productivity growth is not solved. But much is learned, and, building on the paper, more will be learned in the future. Let me first briefly summarize the three major points of the paper.

1. *The Divergent Paths of TFP Growth in the United States and the United Kingdom*

The basic facts laid out in Tables 4 and 5 of the paper, and reduced to their essence in Table 1 here, are striking. TFP growth in the IT-using sector increased substantially in the second half of the 1990s in the United States but decreased substantially in the United Kingdom. Given that the cyclical behavior of the two economies was largely similar over the decade, this suggests the need to look for structural rather than cyclical factors behind this divergence.

2. *IT and Organization Capital*

A preeminent role is given to IT for the performance of the U.S. economy in the second half of the 1990s, so this is a logical place to start looking. The authors point out the complex dynamic relation between IT investment, organization investment, and measured TFP.

Table 1 TFP GROWTH IN THE UNITED STATES AND THE UNITED KINGDOM IN THE 1990s (Percentage)

	1990–1995	*1995–2000*	Δ	*Share in VA*
United States				
Overall	0.9	2.1	1.2	
IT-producing	5.5	11.0	5.5	0.05
IT-using	0.6	1.5	**0.9**	0.95
United Kingdom				
Overall	2.6	1.3	–1.3	
IT-producing	3.9	10.8	6.9	0.03
IT-using	2.6	1.0	**–1.6**	0.97

Here again, it may be worth giving a bare-bones version of the more elaborate model in the paper. Suppose output depends only on organizational capital, C, and labor, N, and is used either for final goods, Y, or for investment in organizational capital, A. Organizational capital depreciates at rate δ:

$$Y = F(C, N) - A$$
$$C = A + (1 - \delta)C(-1)$$

True TFP growth is zero by construction. Measured TFP growth is given by:

$$g \equiv \left(\frac{CF_C}{Y}\right)\frac{\Delta C}{C} - \left(\frac{A}{Y}\right)\frac{\Delta A}{A}$$

Growth of unmeasured organization capital leads to an upward bias in measured TFP growth, and growth of unmeasured organization investment leads to a downward bias.

What is therefore the net effect of organization capital accumulation? Around the steady state, g can be rewritten as:

$$g \equiv \left(\frac{rC}{Y}\right)\frac{\Delta C}{C} - \left(\delta\frac{C}{Y}\right)\left(\frac{\Delta C}{C} - \frac{\Delta A}{A}\right)$$

In steady state $\Delta C/C = \Delta A/A$, so only the first term remains: measured TFP growth exceeds true TFP growth. Out of steady state, the net effect depends on the relation of the growth of capital to the growth of investment. A period of increasing investment is likely to lead to undermeasurement of true TFP growth. This can be seen more clearly by manipulating the previous equation to get:

$$g \equiv \left(r\frac{C}{Y}\right)\frac{\Delta C}{C} - \frac{C}{Y}(1 - \delta)\left[\sum_{0}^{\infty}(1 - \delta)^i\frac{\Delta^2 A}{A}(-i)\right]$$

Measured TFP growth depends positively on the growth rate of organization capital, negatively on the **change** in the growth rate of organization investment. I would have liked the authors to try a specification closer to the spirit of this specification, allowing for the rate of change of organization capital (or the proxy used for it), and a distributed lag in the rate of change of organization investment, constrained to have a sum of coefficients equal to zero. It would have made the results and the estimated dynamic structure perhaps easier to interpret.

3. *Different IT Accumulation Paths in the United States and the United Kingdom?*

The basic implication of the model is that a boom in organization investment leads initially to a decrease in measured TFP, and only later to the promised increase. This suggests a potential explanation for the United Kingdom/United States difference: the boom in IT investment, and thus the boom in induced organization investment, happened earlier in the United States than in the United Kingdom. In the second half of the 1990s, the United States was already reaping the positive effects of high organization capital, and so measured TFP growth was high. The United Kingdom, on the other hand, was still paying the cost of high organization investment, and measured TFP growth was accordingly low. Under this interpretation, the effects will turn positive, and the future may be brighter.

The authors take this hypothesis to the sectoral data, looking at the dynamic relation between TFP growth and proxies for organization capital. This is where the data do not cooperate. The dynamic story appears to work decently for the United States. But it works extremely poorly for the United Kingdom. There is no evidence for a lag structure from IT to productivity growth along the lines suggested by the theory. The authors put a good face on the results, but one cannot conclude that the case has been solved. Let me take each of these points in turn, first focusing on the general line of arguments, then returning to the United States/United Kingdom comparison.

4. *On the General Story*

4.1 HOW WELL ESTABLISHED ARE THE BASIC TFP FACTS?

The first issue is a standard one. Even if one takes TFP growth numbers at face value, the question is, How much can be read in differences in sample means over periods as short as five years? TFP growth varies a lot from year to year. Using the series constructed in the paper, the sample standard deviation of TFP growth over the last 20 years in the United Kingdom is 1.8%, implying a standard deviation for a five-year mean of about 0.8%. A difference of 1.4%, the number in the table for the difference between U.S. and U.K. productivity growth in the IT-using sector for 1995 to 2000, is not that significant. One could probably ask for more time to pass before feeling that there was a puzzle to be explained.

The second issue is that there are many decisions to be made in constructing TFP growth (income or expenditure side, quality weighting of labor, and so on), and so different studies give different results. The

authors of this paper conclude that TFP growth in the IT-using sector increased by 0.9% in the United States from 1990–1995 to 1995–2000 (and overall TFP growth, that is, TFP growth for the whole private nonfarm economy, increased over the same period by 1.2%). This appears to be at the high end of the range of available estimates.

At the low end is Robert Gordon (2000, Table 2), who concludes that there was roughly no increase in underlying TFP growth in the IT-using sector from 1992–1995 to 1995–1999, and a small (0.3%) increase for the whole private nonfarm economy. Next are Oliner and Sichel (2002, Table 4), with an increase of 0.3% in the IT-using sector, and an overall increase of 0.7%. Slightly higher is Jorgenson and Stiroh (2000), with an increase of 0.4% for the IT-using sector (1991–1995 to 1995–1998), and an overall increase of 0.6%. At the high end is the work reported in the *Economic Report of the President* (Council of Economic Advisers, 2001), with an increase of 1% for the IT-using sector, and an increase of 1.2% overall.

All the estimates are (weakly) positive; this is good news. But the magnitudes vary, and one wonders whether plausible variations on hedonic pricing of the IT-producing sector, and thus in the price of IT goods, could not change the allocation of TFP growth between IT-producing and IT-using sectors by a magnitude that would dominate the numbers reported in the previous paragraph and substantially affect the conclusions. This may not affect much the comparison of the United States and the United Kingdom. But it would affect the interpretation of the results: if there was no strong evidence of an increase in TFP growth in the IT-using sector, explanations based on unmeasured organization investment and capital lose a lot of their appeal.

4.2 WHAT ARE THE OUTPUT COSTS OF REORGANIZATION?

It is essential for the authors' thesis that high investment in organizational capital have substantial adverse effects on measured output, and therefore on measured TFP. A study by Lichtenberg and Siegel (1987) on the effects of mergers on TFP is relevant here. Not very surprisingly, they find that TFP in the merged firms goes from 3.9% below the conditional sectoral mean to 1.2% below after seven years. More relevant to the issue at hand, however, is their finding that the improvement is a steady one: there is no evidence of a temporary decrease in measured TFP before reorganization starts paying off.

This evidence is not totally conclusive. Reorganization after mergers may be very different from the types of changes triggered by new IT possibilities. But it makes one want to see more micro evidence that the accumulation of organization capital can have major adverse effects on measured output. This takes me to the next point.

4.3 RETAIL TRADE, THE McKINSEY STUDY, AND WAL-MART

As the authors point out, fully one-third of the increase in TFP growth from the first to the second half of the 1990s in the United States came from the retail trade sector. For this reason, the general merchandising segment, which represents 20% of sales in the sector, was one of the sectors examined in a McKinsey study (McKinsey Global Institute, 2001) aimed at understanding the factors behind U.S. TFP growth in the 1990s.

The study confirmed that there was indeed a large increase in productivity growth, with the growth rate of sales per hour increasing from 3.4% during 1987–1995 to 6.7% from 1995–1999, and it reached two main conclusions: first that more than two-thirds of the increase could indeed be traced to reorganization; second, that much of this reorganization came from the use of IT.

The study also provided a sense of what reorganization means in practice. Improvements in productivity were the result of "more extensive use of cross docking and better flows of goods/palleting; the use of better forecasting tools to better align staffing levels with demand; redefining store responsibilities and cross training of employees; improvements in productivity measurements and utilization rates at check-out." It also showed that, while innovations were first implemented by Wal-Mart, competitors were forced to follow suit, leading to a steady diffusion of these innovations across firms in the second half of the 1990s.

How does the story fit the authors' thesis? In some ways, very well: reorganization, linked with IT investment, clearly played a central role in the increase in TFP growth in the retail sector in the 1990s. But in other and more important ways, the evidence goes against the basic thesis of the paper: the major increase in IT capital took place in the second half of the 1990s. During that period, productivity growth and profits steadily increased. There is no discernible evidence of the adverse effects of organization investment on output, productivity, or profits.

5. *Back to the United States and the United Kingdom*

5.1 THE RELATIVE EVOLUTION OF IT SPENDING

Having stated their hypothesis, the authors proceed to test it using sectoral data. But a natural first step is just to look at the timing of IT investment in both the United States and the United Kingdom and see whether it fits the basic hypothesis.

The authors actually do it, but only in passing, in Figure 1. And what they show does not give strong support to the hypothesis. The figure plots the growth contribution of IT capital in the IT-using sector—constructed as the product of the share times the rate of growth of IT capital. If their

hypothesis were right, one would expect to see high IT investment in the United States early on, and high IT investment in the United Kingdom only at the end of the sample. Actual evolutions are quite different. The United Kingdom appears to have two periods of high IT capital contributions: one in the late 1980s, the other in the late 1990s. It does not seem to be lagging the United States in any obvious way.

This impression is largely confirmed in work by others. Table 2 below is constructed from data in Colecchia and Schreyer (2002, Table 1). It also gives the contribution of IT spending to growth, measured as the product of the share times the rate of growth of IT capital for four subperiods, from 1980 to 2000. The numbers yield two conclusions.

First, the growth contribution of IT appears substantially lower in Europe than in the United States, a conclusion at odds with Figure 1 in the paper, which puts the IT contribution to growth in the United Kingdom, both in computers and software, above that in the United States. Much of the difference appears attributable to the multiplication by 3 by the authors of investment in software, and so the larger share of software in their data, relative to Colecchia and Schreyer. The adjustment may well be justified, but it is obviously rough and is a reminder of the many assumptions behind the data we are looking at.

Second, and more directly relevant here, the acceleration in IT appears to have been stronger at the end of the 1990s in the United States than in the three European countries. The contribution to growth roughly doubled in the last five years from an already high level. It also roughly doubled in the United Kingdom and France, but from a lower level. It increased, but far from doubled, in Germany. If these numbers are correct, and if investment in organization is indeed closely related to investment in IT, it is measured TFP growth in the United States that should have suffered the most from unmeasured investment in the late 1990s, not TFP growth in the United Kingdom.

5.2 WHOLESALE AND RETAIL TRADE AGAIN

The sectoral data in the paper give what looks like a promising lead for solving the case of missing productivity. Table 3, constructed from

Table 2 CONTRIBUTION OF IT TO GROWTH FOR FOUR COUNTRIES, 1980 TO 2000

	1980–1985	*1985–1990*	*1990–1995*	*1995–2000*
United States	0.44	0.43	0.43	0.87
United Kingdom	0.18	0.29	0.27	0.48
France	0.18	0.22	0.18	0.33
Germany	0.20	0.27	0.30	0.38

Tables 4 and 5 in the paper, summarizes the relevant information. The first and second columns report TFP growth in 1990–1995 and 1995–2000. The third shows the change in TFP growth. The fourth shows the share of the two sectors in value added. The last column shows the product of change and share, and shows therefore the contribution of the two trade sectors to the change in TFP growth in the two countries. In the United States, the contribution is 0.8%; in the United Kingdom, the contribution is –1.0%. From an accounting point of view, the evolution of TFP growth in just the trade sector accounts for close to half of the difference between the overall evolution of U.S. and U.K. TFP growth from the first to the second half of the 1990s.

This suggests looking at trade more closely. Indeed, the absolute numbers for U.K. TFP growth in both wholesale and retail for the second half of the 1990s are puzzling. Can it be that TFP growth was actually negative in the United Kingdom during that period? I checked the evolution of labor productivity, using OECD data from the STAN project. For wholesale and retail trade together, that source gives a growth rate of real value added of 3.2% a year, a growth rate for employment of 1.0%, so a rate of labor productivity growth of 2.2%. If the numbers are consistent with those used by the authors, this suggests an unusually high rate of capital accumulation during the period, capital that was not used very productively. This raises the question, Why was it used more productively in the United States?

Unfortunately, I do not know enough about the retail sector in the United Kingdom to give the answer or even help direct the search. In a related McKinsey project (McKinsey Global Institute, 2002) in which I participated, we looked at the evolution of labor productivity in the retail sector in the 1990s in Germany and France. Labor productivity was 1.1% for Germany, 1.5% for France, and 2% for the United States. For the first two countries, regulations affecting the rate at which various retail formats could grow seemed relevant. Such regulations appear much less relevant, however, for the United Kingdom in the 1990s.

Table 3 GROWTH CONTRIBUTIONS OF WHOLESALE AND RETAIL TRADE IN THE UNITED STATES AND THE UNITED KINGDOM

	TFP growth				
	1990–1995	*1995–2000*	*Change*	*Share*	*Contribution*
U.S. wholesale	1.7	5.4	3.7	9.2	0.3
U.S. retail	0.8	5.3	4.5	11.8	0.5
U.K. wholesale	3.3	3.2	–0.1	6.8	–0.0
U.K. retail	0.5	–1.2	–1.7	13.0	–0.2

5.3 CONVERGENCE?

An alternative way of looking at the United Kingdom/United States evolutions in the aggregate is that, for most of the postwar period, European TFP growth was high due to convergence. All Europe had to do was copy, not innovate. And this has largely come to an end.

The problem, as the authors mention, is that, in many countries, convergence has not been fully achieved. While several countries indeed have a level of output per worker close or even higher than the United States, this is not the case for the United Kingdom. According to Table 2 in the paper, U.K. output per worker stands at roughly 70% of the U.S. level.

Theory, however, predicts conditional convergence, not absolute convergence. A country with bad institutions (whatever this exactly means) will not achieve the same level of productivity as one with better institutions. I mention this not because it is a new insight, but because this seems to be happening in Europe. Several countries that were much poorer and had been converging for the past few decades seem now to be growing only at the European average, no longer catching up. Portugal and Greece come to mind, but the United Kingdom, in a less obvious way because the gap is much smaller and thus less visible, may be in the same predicament.

So, was it problems in the use of capital in the trade sector, or was it simply the end of convergence? We still do not know. But, thanks to the paper, we have a better sense of what to look for, and we have a number of lids to open. I wish the authors good luck in solving the case in the future.

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Comment

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1. Introduction

The exceptional productivity performance of the U.S. economy in the period 1995–2000 is well documented (see, for example, Jorgenson 2001): relative to the previous five years, total factor productivity (TFP) growth accelerated by 0.7% (and labor productivity growth by 1%) per year in 1995–2000. What are the sources of this sharp acceleration? Should we expect this higher TFP growth to be a long-term trend for the future, as some argue, or is it just a transitory phenomenon? Basu, Fernald, Oulton, and Srinivasan offer a comparative macroeconomics perspective to these important questions. They bring into the picture the experience of another country, the United Kingdom, which in many dimensions is similar to the United States.

From a long-run perspective, the U.S. and the U.K. economies stand at the same stage of development and share—unlike many other European countries—a similar institutional framework of labor and product markets. From a short-run perspective, the business cycle in the two economies in the 1990s was remarkably akin. I'd like to add that the United States and the United Kingdom were the only two among the developed economies that experienced a substantial rise in earnings inequality in the past 30 years, with analogous characteristics (e.g., both within and between skill groups).

Given these short-run and more structural affinities, one would expect a similar evolution of TFP growth in the 1990s for the U.K. economy. Instead, U.K. TFP growth decelerated by 0.5% (and labor productivity growth by 1%) per year from 1990–1995 to 1995–2000.

How do we explain the missing productivity growth in the United Kingdom (or the exceedingly high productivity growth in the United States)? Basu et al. build a convincing argument on two assumptions. First, because of unmeasured organizational capital that is complementary with information technology (IT) capital in production, TFP growth is mismeasured. Periods of strong investment in IT (and in the complementary organizational capital) are times where mostly output is unmeasured, so true TFP growth is underestimated, whereas periods where the economy has large stocks of IT and complementary capital are times where inputs are grossly undermeasured, and true TFP growth is overestimated. Second, IT investment boomed with a lag of 5 to 10 years in the

U.K. economy, relative to the U.S. economy. Thus, in 1995–2000, TFP growth was underestimated in the United Kingdom and overestimated in the United States, which explains, at least qualitatively, the gap.

This comment is organized into three parts: (1) an exploration of the role of convergence between the United Kingdom and the United States within a Solow-growth model; (2) a deeper look into the retail sector, where the TFP acceleration gap between the two countries is particularly striking; and (3) a quantitative exercise based on the model developed by Basu et al. in Section 4 of their paper.

2. *Convergence*

If one extends the comparison for the two countries back to the early 1980s (see Basu et al., Table 1), it emerges clearly that labor productivity growth was considerably faster in the United Kingdom until the mid-1990s. Basu et al. put it in plain words: "[T]he Europeans were catching up." The authors somewhat downplay the role of transition in their analysis, so here I try to assess if the fact that the United Kingdom was catching up is relevant in explaining the productivity acceleration gap. Intuitively, the transitional dynamics of the United Kingdom would naturally lead to a reduction in labor productivity growth as the economy approaches its steady state.

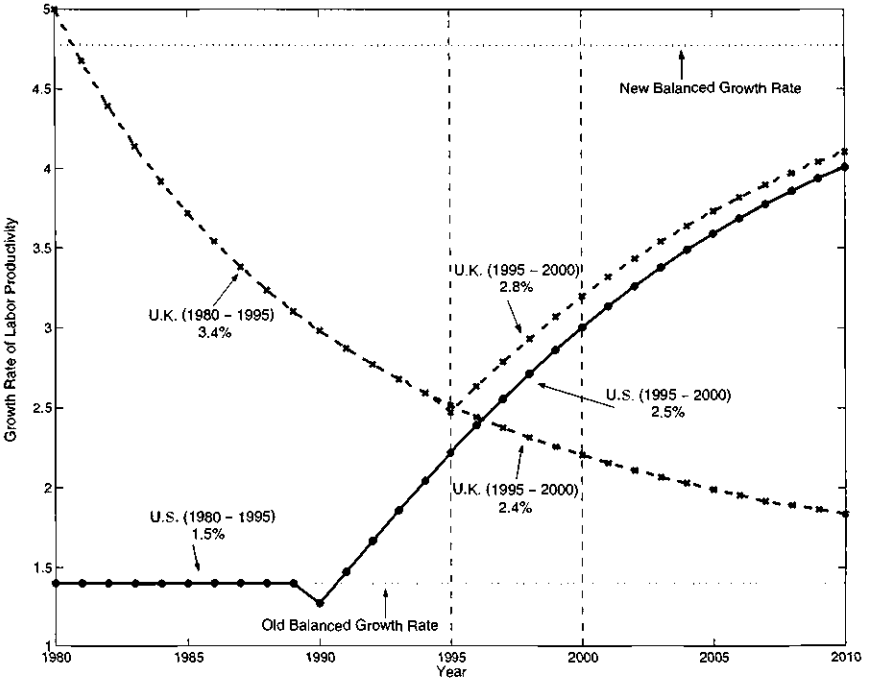
Think of the two countries (indexed by i) in terms of Solow-model economies with capital-embodied technical change: at time t the new investment goods $x_i(t)$ embody a productivity factor $A_i(t) = e^{\gamma_i t}$. The model can be summarized as:

$$x_i(t) = sy_i(t) = sk_i(t)^{\alpha}$$

$$k_i(t) = A_i(t)x_i(t) - (\delta + n)k_i(t)$$

where $k_i(t)$ is capital per worker, s is the savings rate, α is the income share of capital, δ is the depreciation rate, and n is the growth rate of the labor force. The thought experiment is as follows: start the two economies in 1980 with the same parameter vector (s, α, δ, ν, γ) but assume that the United States is already on its balanced-growth path, while the United Kingdom is endowed with lower capital per worker, so it has a faster growth rate of labor productivity and slowly converges toward the U.S. level. In 1990 a technological breakthrough raises permanently capital-embodied productivity growth to γ' in the U.S. economy. From this simple exercise, one can learn the implied labor productivity growth in the United Kingdom in the period 1995–2000 under two scenarios: (1) the acceleration in technological change does not spill over to the United

Figure 1 CONVERGENCE BETWEEN THE UNITED KINGDOM AND THE UNITED STATES IN A SOLOW MODEL ECONOMY



Kingdom and (2) the acceleration occurs with a lag of 5 years in the United Kingdom.[1]

To calibrate the model, I set $\gamma = 1.7\%$ and $\gamma' = 5.7\%$ to match the data on average labor productivity in the United States in the period 1980–1995 and 1995–2000, respectively. I chose the initial level of capital in the United Kingdom so that along the transition in the period 1980–1995, average yearly productivity growth is 3.4%, as documented in Table 1 by the authors.[2]

What can we conclude from this simple exercise on the role of catch-up and transitional dynamics? Figure 1 shows that, under the first scenario, the U.K. rate of labor productivity growth implied by the transitional dynamics in 1995–2000 is 2.4%, which is well below 2.9%, the actual data from Table 1. In the absence of a rapid technological spillover to the

1. The first scenario corresponds to a lag of 10 years or more, assuming that we are interested in the period until 2000.
2. The other parameters are set as follows: $s = 15\%$, $\alpha = 0.45$, $\delta = 5\%$, and $n = 1.5\%$. The somewhat high value of the capital share reflects the presence of human capital.

United Kingdom, pure convergence forces push the implied labor productivity too low compared to the data. Under the second scenario, labor productivity grows at an average yearly rate of 2.8%, thus the combination of the authors' view that the U.K. "implementation lag" is around 5 years together with catch-up forces explains the deceleration in full (in fact, it just overexplains it).[3]

An obvious question arises: Why did the United Kingdom adopt this more productive technology later? A satisfactory answer would require a full investigation. Here, I will limit myself to a brief speculation. In Table 3, Basu et al. document the educational characteristics of the labor force in the two countries. The difference with the United Kingdom does not lie so much in the average numbers of years of schooling, but rather in the fact that the United Kingdom has a much larger fraction of workers with specific skills associated with vocational training. At least since Nelson and Phelps (1966), numerous researchers argued that general education is a key force in technology adoption. In a recent mimeo, Krueger and Kumar (2003) embed the Nelson and Phelps mechanism into an equilibrium model and show that an acceleration in the growth rate of the frontier technology will increase the TFP growth gap between an economy with abundant general skills (like the United States) and an economy mostly endowed with specific skills (like the United Kingdom and most of the other European countries).

The careful reader will have noticed that the predictions of this exercise are relevant to explain the *labor productivity* acceleration gap between the two countries, but not the TFP growth differential. However, this is true only if all inputs are correctly measured. Suppose that the productivity improvements in investment goods captured by the factor $A(t)$ are completely missed by statisticians. In this case, measured total factor productivity $z(t)$ is obtained residually from the production relationship $y(t) = z(t)\hat{k}(t)^{\alpha}$, with $\hat{k}(t) = x(t) - (\delta + n)\hat{k}(t)$. In other words, $z(t)$ is an average of all past values of $A(t)$ weighted by the investment flow in each year.

What are the predictions of our simple calibrated model for TFP? Simulations under the same exact parametrization show that the model generates an acceleration in TFP growth for the United States of 1.5% and an acceleration in TFP growth for the United Kingdom of 0.3% under the first scenario and of 0.7% under the second scenario. Although the model produces larger accelerations in absolute value in the two economies (in particular, it does not generate a TFP deceleration for the United

3. Obviously, if all inputs are correctly measured, the predictions of this exercise are relevant only to explain the labor productivity acceleration gap between the two countries. TFP is constant over time.

Kingdom), it predicts a gap of roughly 1% between the two countries, in line with the data of Table 1.

3. *Institutions in the Retail Sector*

A comparison between Table 4 and Table 5 documenting the size of the TFP acceleration from 1990–1995 to 1995–2000 by industry in the two countries shows a relatively similar sectoral performance with one important exception: in the retail trade sector, TFP growth accelerated by 4.5% per year in the United States, whereas it decelerated by 1.9% per year in the United Kingdom. The authors note this puzzling divergence, but they do not search for its specific causes. It is clear, however, that an argument based on the dynamics of unmeasurable organizational capital is unlikely to account for the TFP acceleration gap in the retail industry. Tables 6 and 7 show that the share of IT investments in value added did not change much between 1990 and 2000 in either country in this sector.

A report of the McKinsey Global Institute (1998) sheds some light on the puzzle: between 1993 and 1996, fearing a massive "high-street flight" of retail stores toward the periphery of towns and cities, the U.K. government voted a series of planning restrictions establishing that local planning authorities should promote the development of small retail stores in town centers and restrict the concession of planning permissions for new stores or for the extension of existing stores outside town centers. By contrast, land regulations in the United States put no significant restrictions on retailers' location decisions.

As a result of these stringent planning guidelines, a large fraction of retail stores in the United Kingdom have suboptimal size and are not located optimally on the territory. McKinsey estimates the productivity loss associated with these strict regulations to be roughly 10% at the sectoral level, so the entire TFP deceleration in the U.K. retail sector (– 1.9% per year compounded over 5 years) could be explained through this channel. Retail trade is a large industry, accounting for about 12% of aggregate value added in both economies, thus these institutional restrictions alone can potentially explain over 60% of the differential TFP acceleration between the two countries.[4]

4. *Complementary Capital*

The equilibrium model of Section 4 allows Basu et al. to obtain the structural equation in equation (9) that relates the bias in TFP growth to the

4. Regulatory restrictions that have a significant impact on store size and productivity are not uncommon in other parts of the world. For example, in Japan, until 2000, the large-scale retail law limited greatly the entry of stores larger than 1,000 square meters.

change in the stock of complementary capital. Consider a special case of the model where $g = r$ (the growth rate of the economy equals the interest rate) and $\sigma = 1$ (a unitary elasticity between IT capital and the complementary organizational capital is necessary to have a balanced growth path in the model), then one can rewrite equation (9) as:

$$\Delta TFP_t^* - \Delta TFP_t = \frac{C}{Y^{NT}}\left(1 - r - \delta_c\right)\left[\Delta C_t - \Delta C_{t-1}\right] \tag{1}$$

where ΔTFP_t^* is true TFP growth in year t, C/Y^{NT} is the long-run (or steady-state) ratio of the stock of complementary capital to output produced in the non-IT industries, and δ_c is the depreciation rate of complementary capital. Given the assumptions made on the substitutability between IT capital and C capital in production, the growth rate of complementary capital at time t can be written also as:

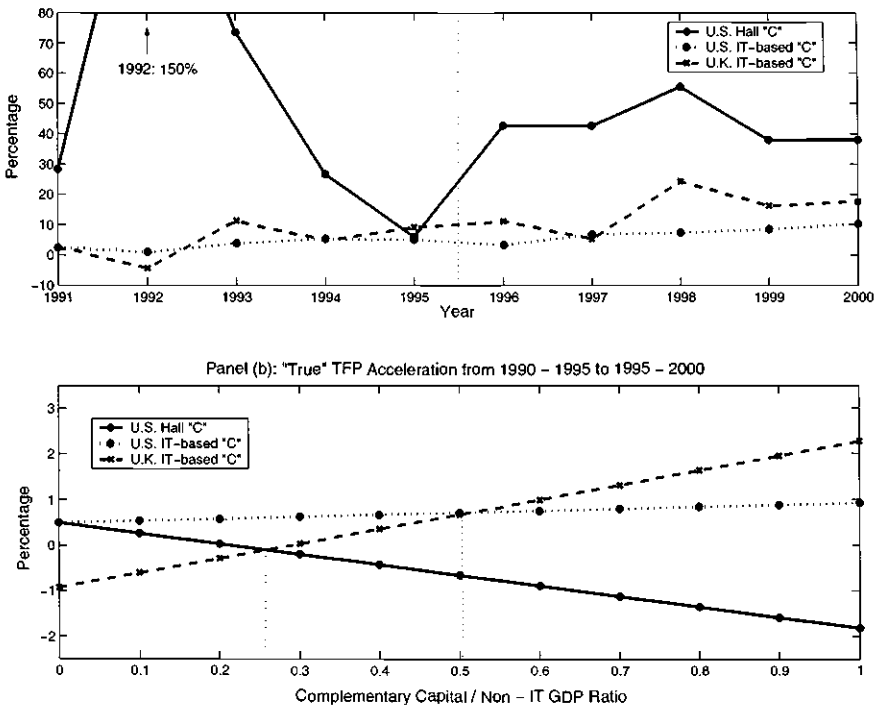
$$\Delta C_t = \Delta K_t^{IT} + \Delta p_t \tag{2}$$

where ΔK_t^{IT} is the growth rate of IT capital, and Δp_t is the change in the price of new IT investment relative to non-IT output.

The authors use equations (1) and (2) as their statistical model in a series of cross-sectional regressions where different rates of IT investment across industries provide a source of variation to estimate the size of the bias in TFP growth due to the missing C capital. The results are encouraging, but not as sharp as one would hope. The main reason of the weak statistical significance, in my view, lies in the very same point the authors are trying to prove: if IT is truly a general-purpose technology, then we should expect similar investment rates across all industries, which makes the cross-sectional data not very informative. Indeed, Tables 6 and 7 show that, with the exclusion of a few outliers (like mining, real estate, and communications), the variability of investment rates in IT among industries is rather small.

I take a different approach for setting the complementary capital model in action. The spirit of the exercise will be as follows. From the data on IT capital and prices and from equation (2), one can construct growth rates of C capital for the whole decade 1990–2000 for both countries. Together with a common parametrization for the pair (δ_c, r), one can then compute the true TFP growth ΔTFP^* in the two countries for different values of the complementary capital output ratio, which is unobservable. Finally, assuming that the United Kingdom and the United States have the same long-run C/Y^{NT} ratio along their balanced growth (and this will be the case if the two economies differ only in the *timing* of the productivity shock, as in the convergence exercise), one can ask, What is the specific value of

Figure 2 GROWTH RATE OF COMPLEMENTARY CAPITAL



C/Y^{NT} that rationalizes the TFP acceleration differential? In other words, given the scarcity of information contained in the industry-level data, and the fact that C capital is not directly measurable, the best we can do is engage in the art of "reverse engineering." I will express later a subjective judgment on the plausibility of the number obtained.

In the exercise, I will also use another indirect source of measurement of C capital growth constructed from Hall's (2001): the difference between the stock-market valuation of firms and the book value of their physical assets provides an implicit measure of the stock of intangibles in the U.S. economy.[5]

The top panel of Figure 2 plots ΔC_t in the United States measured through both IT-based and Hall's methods, and ΔC_t in the United Kingdom measured with the IT-based approach. The U.K. IT-based estimate of C capital growth is higher in the second half of the sample. The

5. Hall's data are available from http://www.stanford.edu/~rehall/. To my knowledge, there is no similar attempt to obtain an estimate of intangible capital for the U.K. economy.

IT-based measure of *C* capital growth for the United States is slightly increasing over time, albeit at a slower pace than the U.K. measure; instead Hall's U.S. *C* capital growth is much higher in the first half of the sample. Taken together, these numbers mean that the correction of the bias in TFP growth will go in the right direction.

The lower panel of Figure 2 plots—for a range of values of the C/Y^{NT} ratio—the true acceleration in TFP between 1990–1995 and 1995–2000 calculated using in equation (1) the three series for ΔC_t just constructed.[6] Note that when this ratio is zero, we obtain the measured ΔTFP of Table 1. The point where the U.S. and the U.K. lines cross corresponds to the value of the long-run C/Y^{NT} ratio that reconciles the measured U.S./U.K. differential in *TFP* acceleration with equal true *TFP* growth.

Using Hall's estimates for the growth in the stock of intangible capital in the United States in the 1990s, this value is 0.26, which corresponds to a true TFP deceleration of 0.1% per year in both countries. However, if the U.S. stock market were overvalued in the 1990s, this source of information on intangibles can be imprecise. The alternative IT-based measure of *C* capital for the United States proposed by the authors tells us that the long-run C/Y^{NT} ratio that solves the puzzle is around 0.5, which corresponds to a true acceleration of 0.7% per year in both economies.

How reasonable are these two numbers? I argue that they are quite plausible. To understand, it is useful to express them in terms of aggregate output *Y* (non-IT value-added Y^{NT} accounts for 95% of total output in the United States). Take the mean of these two estimates for C/Y, which is 0.35. Given the assumed depreciation rate, this number would imply that steady-state investment in *C* capital is less than 6% of output, very close to the current share of IT investment in U.S. data, which is around 7%. A C/Y ratio of 0.35 is a conservative estimate in light of the recent work by McGrattan and Prescott (2002, Table 2), who estimate the stock of intangible capital in the United States to be around 0.65 of aggregate gross domestic product (GDP) and, after reviewing the literature, conclude that a reasonable range for this ratio is between 0.5 and 1.

To conclude, this calculation provides support, from a different angle, to the authors' main argument: theory is *still* ahead of measurement. We have rich models suggesting that organizational capital plays an important role in macroeconomics, especially in phases of technological transformation, but we are lacking reliable direct measurements. However, I have also argued that one should not neglect more traditional explanations of productivity differentials, like convergence forces and institutions.

6. I have assumed that, in both countries, the depreciation rate for *C* capital δ_c is the same as the depreciation rate for IT used by the authors (16%), and that $r = 4\%$.

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Discussion

Several participants remarked on the role of the wholesale and retail trade in the authors' story. Mark Gertler suggested that the TFP slowdown in the United States appears to be partly associated with a slowdown in these sectors, which in turn implies that there is something important about these particular sectors that economists should try to understand. John Fernald remarked that the wholesale and retail trade contributed to three-fourths of the difference in TFP growth between the two countries. He also remarked that net entry alone—the entry of Wal-Mart and the exit of Kmart—explains the productivity performance of the retail sector. Robert Shimer counseled caution in the use of Wal-Mart as an example of the retail trade. He pointed out that by joining together successes such as Wal-Mart and failures such as Kmart, one would get a more realistic picture of the U.S. retail trade in the 1990s. In response to Olivier Blanchard's discussion, Nick Oulton noted that though planning regulations in the United Kingdom could lower the level of TFP, they should not affect the growth rate of TFP. He contended that the small size of individual stores should not affect the incentives for retail chains to invest in IT.

The theme of the choice of sample countries was raised by several participants. Mark Gertler questioned the authors' identification assumption that there are many macroeconomic similarities between the United Kingdom and the United States. He pointed out that according to the authors' Table 1, there was moderate growth in output and strong growth in investment in the United States between 1990 and 1995, but there was low output growth and no net investment in IT in the United Kingdom.

Athanasios Orphanides suggested that the authors expand their sample of two countries to include Australia. It was his view that this approach would help to deal with the identification issue pointed out by Mark Gertler because Australia experienced measured productivity growth even larger than that in the United States but was similar to the United Kingdom in terms of initial conditions and catching up in the 1990s. Kjetil Storesletten suggested that Germany and Sweden would be another interesting pair of countries to compare. He observed that there was a rapid acceleration of TFP growth in the 1990s in Germany, but little growth in IT investment. In the 1990s, Sweden, like the United States, saw sharply falling unemployment and an acceleration in TFP, along with widespread use of IT.

Several participants had concerns about data issues. Robert Shimer contended that the authors were wrong to dismiss the role of declining unemployment in explaining the differential behavior of TFP growth in the United States and the United Kingdom. He maintained that the bigger decline in unemployment in the United Kingdom, resulting in the long-term unemployed being drawn into employment, might contribute more than the authors estimated to the slow growth of TFP. Nick Oulton responded that the authors had controlled for the education characteristics as well as the gender and age of the labor force in the United Kingdom, so composition effects are unlikely to explain the differential TFP performance between the two countries. In response to Gianluca Violante's discussion of the aggregation of different qualities of labor, Susanto Basu agreed that big deviations from Cobb-Douglas do matter. He contended that the authors' aggregation procedure is not subject to this problem because they use a Törnqvist average of shares over time, rather than a pure Cobb-Douglas, to aggregate.

Mark Gertler was curious about whether there are any observable indicators of investment in complementary capital. In response to this question, Susanto Basu drew the attention of the audience to several firm-level studies associated with Brynjolfsson and co-authors from the pre-bubble period in the United States. These studies document that a $1.00 increase in IT investment is associated with a $5.00 increase in the stock-market value of a firm, suggesting the order of magnitude of complementary capital investments. The studies also indicate that returns to investments in IT are typically normal or low initially, but large with a five-year lag. He noted that this finding was consistent with the story of the paper.

Daron Acemoglu pointed out that the authors' lag story has additional first-order testable implications. He wondered whether investment in IT would have made sense with lags of the length necessary for the authors' story given that firms could have invested at the risk-free rate. Second, he

asked whether a production function with decreasing returns to scale in factors other than the unobservable complementary capital would fit other features of the data.

Eva Nagypal commented that the authors do not discuss the distribution of TFP between newly created and existing firms. She suggested that differences in the composition of firms between the United States and the United Kingdom could explain the contrasting behavior of TFP in the two countries. While creation and destruction of establishments is similar in the two countries, growth in new establishments is much higher in the United States, and a large fraction of TFP growth is attributable to them.

Finally, the authors responded to some concerns of the discussants about data. Nick Oulton noted that differences between national accounts methodology in the United States and the United Kingdom make cross-country comparisons difficult. In particular, in the United Kingdom, software investment is misclassified as the purchase of an intermediate input, resulting in a substantial understatement of information and communications technology (ICT) investment as a whole. With an appropriate adjustment for this misclassification, the growth accounting contribution of ICT is similar in the United Kingdom and in the United States, even though stocks are smaller in the United Kingdom. In response to Olivier Blanchard's discussion, John Fernald pointed out that estimates of the acceleration in non-ICT production depend on whether the data used is product data or industry data. He commented that taking account of investment adjustment costs would strengthen the story that TFP growth took place mainly in non-ICT-producing sectors because sectors that were using IT, not producing it, experienced a surge in complementary investment that diverted resources.