On Technological Convergence among Countries. A Comment on Patel and Pavitt

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In a recent article, Patel and Pavitt (1994) presented statistical evidence related to the hypothesis of 'striking differences—even divergences—in the rate and direction of technological accumulation in the industrial countries' (p. 770). Although the theoretical framework Patel and Pavitt presented to explain their statistical findings is not without appeal, one might argue that it tends to put a large degree of emphasis upon those factors in technological development that have been identified as causing 'cumulativeness' and persistent differences between countries, or, at a lower level of aggregation, firms. In previous work with Luc Soete (Soete and Verspagen, 1993, 1994), I stressed that the empirical facts tend to support a hypothesis which, contrary to Patel and Pavitt, takes into account a mix of factors related to the international diffusion of knowledge and convergence of national levels of technology, investment and specialization structure on the one hand, and cumulativeness of knowledge development and specialization patterns on the other hand [see, for example, Dosi (1988) for an overview of these various factors]. During recent decades (Soete and Verspagen, 1993, 1994) those factors related to convergence seem to have been slightly dominant in the OECD area.

This conclusion is in obvious contrast with the one drawn in the work by Patel and Pavitt (1994). In this note, I will argue that this contrast is due to an interpretation of the empirical evidence by Patel and Pavitt which is at least partly open to criticism. My comments will be focused on two of their tables related to technological indicators at the country level.

Firstly, Patel and Pavitt, on the basis of their table 1, which gives the standard deviation (SD) of industry-financed R&D to GDP ratios among 17 advanced OECD countries, argued that 'there are no statistical signs of convergence in the industry-funded shares over time, since the standard deviation of the distribution has not decreased over time. On the contrary, it

has increased markedly in the 1980s, suggesting technological divergence among countries' (p. 763).

The coefficient of variation (defined as the ratio of the mean of a distribution to the SD) measures percentual deviations from the mean, rather than the absolute deviations from the mean in the SD. In the convergence debate, the coefficient of variation is therefore generally accepted as a more useful indicator of convergence than the 'raw' SD (e.g. Dollar and Wolff, 1993). In the data by Patel and Pavitt, it is certainly true that the SD of industry-financed R&D as a fraction of GDP has risen over time. However, the same holds for the mean of the variable, so that we may expect the results on convergence to differ between the coefficient of variation and the 'raw' SD. This is documented in Table 1.

This table shows that the SD, compared with the mean, in fact fell consistently over the 1967–1991 period. Although this result is not a robust statistical test of convergence, it certainly shows that the conclusion of divergence drawn by Patel and Pavitt is not supported when more appropriate indicators are used.

The second point relates to their table 6, which documents correlations between countries' technological specialization patterns as measured by the so-called 'revealed technological advantage' index (RTA). It is worth recalling that this index for country i and sector j is defined as the share of i in total patenting from sector j, divided by the share of i in total patenting in all sectors. A value of 1 indicates no particular specialization, whereas values smaller (larger) than one indicate negative (positive) specialization of country i in sector j.[1]

Patel and Pavitt calculated RTA indices for 34 sectors and 19 countries, and presented the correlation coefficients between the 171 meaningful pairs of countrywise specialization patterns that arose. They found that 'only' 18% of these 171 correlation coefficients were significantly positive, and on the basis of this, they concluded that this 'confirms that countries tend to differ markedly in their patterns of technological specialization' (p. 767).

Note that by definition, the weighted average of countries' RTA-indices in a sector is 1, and the same holds for the weighted average of sectors' RTA-indices in a particular country. Thus, if we set up a matrix of RTA-indices for 34 sectors and 19 countries, as Patel and Pavitt did, we would

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[1] This points to a well-known problem with RTA-like indices, namely that measures of negative specialization are squeezed into the interval from 0 to 1, whereas positive specialization is measured on the interval from 1 to infinity. In other words, the RTA index is asymmetric. This can be changed by taking the log of the RTA, or by applying the transformation (RTA − 1)/(RTA + 1). Here I follow Patel and Pavitt (1994) in not bothering to make any of these transformations, although the conclusions in this note are not sensitive to that.

TABLE 1. Ratio of SD to Mean (Coefficient of Variation) of Industry-financed R&D to GDP Ratios in 17 OECD Countries, 1967–1991

	Incl. US	Excl. US
1967	0.70	0.73
1971	0.60	0.62
1981	0.57	0.60
1991	0.52	0.54

Source: Calculations on the basis of Patel and Pavitt (1994, table 1).

expect that, on average, for each value >1 in any particular row or column of this matrix, there would be a value <1 in the same row or column.[2] In other words, the RTA index has been devised to express relative differences, not similarities.

On average, therefore, one would expect that if one correlates two rows from this RTA matrix, as Patel and Pavitt do, a negative correlation arises. This only holds on average, though, because it is perfectly possible that, for some technological or economic logic, certain countries are specialized in the same fields as certain other countries. On average, however, not every country can be specialized in the same area, so there must be a fairly large number of negative correlations.

In order to get a more intuitive feeling of how many of the 171 correlation coefficients could be expected to be positive or negative, I undertook a simple Monte Carlo experiment. In this experiment, a 19 × 34 matrix of random numbers was drawn from a uniform distribution on the interval [0,1).[3] This matrix was used to calculate the RTA indices, which were then correlated in the 'country' dimension. The experiment was repeated 100 times with different random seeds. The mean value of the fraction of (significantly) positive and negative correlations is reported in Table 2.

The table confrrms the expectation that the majority of correlation coefficients is negative. The number of significantly negative correlations is also proportionally larger than the significantly positive ones. The standard errors of the fractions are fairly small in comparison with the fractions themselves, with the exception of the fraction of significantly positive correlations. This shows that if countries' patenting were purely distributed randomly over activities, one would on average expect a little less than

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[2] Actually, this holds only if the country sizes are not extremely different.

[3] The random number generator in Borland Pascal 7.0 was used to set up the experiment.

TABLE 2. The Mean Value of the Fraction of Positive and Negative Correlations in the Monte Carlo Experiment for a 19 × 34 Matrix of RTA Indices

	Mean	Standard error
Negative correlations	0.622	0.022
Significantly negative correlations	0.055	0.022
Positive correlations	0.378	0.008
Significantly positive correlations	0.013	0.016

Significant values are taken as values with $P < 0.05$, as in Patel and Pavitt.

two-thirds of the entries in the Patel and Pavitt correlation matrix to be negative, with only a small proportion of them being significant (either positive or negative).[4]

It is obvious that the Patel and Pavitt matrix is not based upon random numbers. For example, they found that 25.7% of all their correlation coefficients were significant. The majority of those (18.1 percentage-points) were significantly positive. Overall, they found that 60.8% of their correlation coefficients were positive. Thus, compared with the results from the random distribution, they found a relatively large number of (significantly) positive correlations, whereas they based the above-cited conclusion with regard to the 'marked differences' between countries upon the supposed finding that there were 'too few' significantly positive coefficients.

It is not obvious what their results, when interpreted correctly, imply exactly. Whether the large number of positive correlations is due to an uneven distribution in country size (as measured, for example, by the number of patents taken out) or to some systematic factors behind the technological development reflected in the patent statistics is not clear. There is, however, a clear danger of getting stuck in tautologies when correlating RTA indices across different dimensions, because the index itself has been divised to measure 'relative' differences and not similarities. But above all, it is clear that the specific pattern of correlations observed by Patel and Pavitt is not an indication of 'marked differences' between countries.

Overall, the conclusion must therefore be that, at least in these two cases, which are the bulk of the 'macro' evidence in their paper, Patel and Pavitt's conclusions with regard to cumulativeness and divergence of technological levels cannot withstand closer inspection. It is beyond the scope of this note

[4] I also undertook experiments in which the distribution from which numbers were drawn was (approximately) normal. This yields results which are almost exactly equal to those reported in Table 2.

to present more elaborate evidence supporting the opposite case of convergence. To 'conclude that technological gaps among the OECD countries are here to stay' (p. 759), seems, however, a bit too premature.

Acknowledgements

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