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## *Integration of Macroeconomic and S&T Policies for Growth, Employment and Technology*

## *MACROTEC*

FINAL REPORT

EUR 21534

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# EU RESEARCH ON SOCIAL SCIENCES AND HUMANITIES

# Integration of Macroeconomic and S&T Policies for Growth, Employment and Technology

## MACROTEC

### Final report

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## Preface

Within the Fifth Community RTD Framework Programme of the European Union (1998–2002), the Key Action 'Improving the Socio-economic Knowledge Base' had broad and ambitious objectives, namely: to improve our understanding of the structural changes taking place in European society, to identify ways of managing these changes and to promote the active involvement of European citizens in shaping their own futures. A further important aim was to mobilise the research communities in the social sciences and humanities at the European level and to provide scientific support to policies at various levels, with particular attention to EU policy fields.

This Key Action had a total budget of EUR 155 million and was implemented through three Calls for proposals. As a result, 185 projects involving more than 1 600 research teams from 38 countries have been selected for funding and have started their research between 1999 and 2002.

Most of these projects are now finalised and results are systematically published in the form of a Final Report.

The calls have addressed different but interrelated research themes which have contributed to the objectives outlined above. These themes can be grouped under a certain number of areas of policy relevance, each of which are addressed by a significant number of projects from a variety of perspectives.

These areas are the following:

- ***Societal trends and structural change***

16 projects, total investment of EUR 14.6 million, 164 teams

- ***Quality of life of European citizens***

5 projects, total investment of EUR 6.4 million, 36 teams

- ***European socio-economic models and challenges***

9 projects, total investment of EUR 9.3 million, 91 teams

- ***Social cohesion, migration and welfare***

30 projects, total investment of EUR 28 million, 249 teams

- ***Employment and changes in work***

18 projects, total investment of EUR 17.5 million, 149 teams

- ***Gender, participation and quality of life***

13 projects, total investment of EUR 12.3 million, 97 teams

- ***Dynamics of knowledge, generation and use***

8 projects, total investment of EUR 6.1 million, 77 teams

- ***Education, training and new forms of learning***

14 projects, total investment of EUR 12.9 million, 105 teams

- ***Economic development and dynamics***

22 projects, total investment of EUR 15.3 million, 134 teams

- ***Governance, democracy and citizenship***

28 projects; total investment of EUR 25.5 million, 233 teams

- ***Challenges from European enlargement***

13 projects, total investment of EUR 12.8 million, 116 teams

- ***Infrastructures to build the European research area***

9 projects, total investment of EUR 15.4 million, 74 teams

This publication contains the final report of the project 'Integration of Macroeconomic and S&T Policies for Growth, Employment and Technology', whose work has primarily contributed to the area 'The relationship between employment and growth'.

The report contains information about the main scientific findings of MACROTEC and their policy implications. The research was carried out by ten teams over a period of 28 months, starting in April, 2002.

The abstract and executive summary presented in this edition offer the reader an overview of the main scientific and policy conclusions, before the main body of the research provided in the other chapters of this report.

As the results of the projects financed under the Key Action become available to the scientific and policy communities, Priority 7 'Citizens and Governance in a knowledge based society' of the Sixth Framework Programme is building on the progress already made and aims at making a further contribution to the development of a European Research Area in the social sciences and the humanities.

I hope readers find the information in this publication both interesting and useful as well as clear evidence of the importance attached by the European Union to fostering research in the field of social sciences and the humanities.

J.-M. BAER,

Director

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**Abstract**

In European countries, and especially in the European Commission itself, macroeconomic policy on the one hand and science and technology policy on the other hand are almost totally detached from each other. It is widely recognised that technological change can have a significant impact on economic growth, as underlies the production function in economics and the 'linear model' of innovation studies and governmental policy-making. The reverse impact of macroeconomic conditions on technology has however been given little coherent study. The MACROTEC project thus chose to focus on this overlooked linkage.

Our initial work consisted of a large-scale literature survey, which did find many attempts to approach the issue of concern, but the literatures were scattered and mostly 'heterodox'. Data were collected both for individual countries and on a cross-country basis. Analysis of the data showed consistently at both levels that there appeared to be a pattern of causation that ran from the macro-economy to technology, and that this was at least as evident as the 'orthodox' link from technology to growth. This finding ran counter to the basic precepts underlying 'supply-side economics' and the premises behind current macro-economic policy-making in the EU and many member states. An analytical explanation is therefore given to account at the macro level for why expansion of aggregate demand may have real and sustained effects of enlarging aggregate supply. In addition, we provide some indications of 'transmission mechanisms' at the micro, meso and macro levels of how these demand changes may feed through into expanding technological achievements.

One of these 'transmission mechanisms' consists of skill changes. Our work traced the well-known pattern of exacerbated inequality in earnings in the late 20$^{th}$ century and related it to the 'Solow paradox' of productivity slowdown at a time of apparent radical technological change. We suggest ways in which the technical change can causally explain the widening inequality which in turn accounts for the slowdown of productivity, but also why future technical change is unlikely to have such adverse effects.

Other 'transmission mechanisms' operate at the micro level of new firm formation and industrial structure, and at the macro level of public/private RTD interaction, as well as the international level of trade and FDI flows.

From this combination of empirical research and analytical reformulation, we have been led to advocate a new 'Schumpeterian macroeconomics'. This would take some ingredients from old Keynesian viewpoints of the key role of supporting aggregate

demand, but would mesh them with the need to ensure that any such expansion was funnelled into raising technological and organizational levels. Complementarities will need to be developed, not just between demand-oriented and supply-oriented macro policies, but also between public and private sector actions, and between foreign-based and domestic-based activities. The Europe we observe fissures these into alternatives rather than seeing their integration, perhaps most strongly in the candidate countries. The EU has to an extent, and no doubt unintentionally, helped to foster seeing policy choices in this way. We conclude that an attempt to re-integrate macroeconomic policies with technology policies at the national and supranational levels is long overdue.

## I. EXECUTIVE SUMMARY[1]

Macro policy-making in Europe, at both the national and the supranational levels, maintains a rigid distinction between macro-economic policy on the one hand and macro-level technology policy on the other. The European Commission, for which these two areas constitute its main policy-making focus, is a prime example. On the one side is the formulation of EU economic policy, couched in terms of the Growth and Stability Pact, on the other side is EU technology policy, spearheaded by the Framework Programmes. The key issue that has been considered in the MACROTEC project is the lack of interconnection between these two great fields for policy, not just in the EU but within its Member states, in the candidate countries, and indeed in the great majority of countries today.

The aim of the project was to investigate to what extent macroeconomic and S&T policies in several European countries are mutually compatible; to assess how compatibilities and incompatibilities between macroeconomic and S&T policies affect employment, growth and technical change in the selected European countries; and to suggest new policy approaches and policy mixes which should integrate macroeconomic and S&T policy in order to promote growth and structural change.

For the two-year project, a team was assembled that consisted of 10 partners in 9 different countries, in order to provide the diversity of experience required for such an ambitious undertaking. The countries represented were: from the Member states of the EU, the UK, France, the Netherlands, Austria, Spain and Greece; from the accession countries, Poland and Hungary; and from the other candidate countries, Bulgaria. At several of the meetings speakers were invited to give comparable experiences from other European countries, both member states and others.

The work was guided by an experienced Steering Committee, whose contributions proved invaluable, and dissemination was focused on a Users Committee. membership of both was spread across most of the countries involved in the project. We also aimed dissemination at EU policy-makers in Brussels.

Although the original intention was to examine policy structures in detail, in the course of the project this gave way to the larger policy issue of integrating macroeconomic with

[1] This paper draws upon the findings of all the members of the MACROTEC project, though space limitations preclude giving their work full credit or explanation. I am grateful to all of them, and also to our administrator at DG Research, Peter Fisch, for suggesting that this paper be written. I am of course solely responsible for its content.

S&T policy as a whole, in line with the underlying rationale. This is what we concluded by describing as a call for a new 'Schumpeterian macroeconomics', an objective not envisaged at the outset of the project. Moreover, external considerations relating to developments in EU policy, particularly the setting of the 'Barcelona target' for raising EU R&D intensity, came to the forefront in relation to our policy advice, and the directions of investigation as well as the outputs and dissemination had to be remodelled accordingly.

**1. The literature review – WP1**

The literature survey unearthed a variety of views on the macro relationship between economic and technology policies. In relation to long-run growth, the impacts of macro-economic policy can be divided into: i) short-term disequilibrium (e.g. inflation, unemployment, macroeconomic volatility); ii) 'structural dysfunctioning' (e.g. inequalities, labour market hysteresis, uncertainty); and iii) trade orientation (e.g. trade, economic integration). Although 'orthodox' economists' approaches were addressed, their emphasis on equilibrium and supply-side economics severely limited their usefulness for appraising such questions, and the survey found that alternative 'heterodox' approaches more consistently assessed these sorts of impact. The four principal alternatives surveyed were: i) Neo-Kaldorian views about 'cumulative growth', where growth is more demand-driven and the aim is to be compatible with Kaldor's 'stylised facts' about economies in the long term; ii) Regulation school views about regimes of accumulation and differences between countries in modes of 'regulation'; iii) National Systems of Innovation views, widening into interpretations of 'social systems of innovation'; and iv) Neo-Schumpeterian approaches based on evolutionary growth models, drawn from both micro and macro foundations.

Despite the difference in analytical perspective – indeed what we would claim to be a quite inappropriate analytical foundation – surveys produced by mainstream economists from the OECD in the course of our project came to substantially the same conclusions about the empirical nature of these relationships, which gives us some confidence in the robustness of our results. Our views can also be compared with those of the 'new growth theory', which can be seen as an intermediate position between orthodoxy and heterodoxy, in which some of the elements we take to be endogenous are still treated as exogenous. Such an approach underlies EU objectives such as the 'Barcelona target' for raising R&D intensity in the EU to around 3% of GDP. We agree in spirit with such objectives but find greater analytical and policy problems than do new growth theorists in trying to attain them.

## 2. The effects of macroeconomic performance on technology – WP2

One of the main by-products of the research was the creation of extensive cross-country datasets. This combined a search for cross-country consistency on the one hand with a need to maintain temporal consistency over time on the other hand. Although we did not complete the latter task during the two years of the project, we believe that the substantial collation of data available on the MACROTEC website (http://www.sussex.ac.uk/spru/macrotec) provides a more accessible source for other scholars (and policy-makers) wishing to pursue queries in this area.

For reasons that in analytical terms will be spelled out in WP4 below, our prescriptions for the interaction between economic growth and technological change turned out to be at odds with the prevalent 'monetarist' or 'supply-side economics' view underpinning contemporary EU macroeconomic policy. What we found as empirical support for our new view is that increases in output (e.g. real GDP) frequently precede increases in measured technology effort such as R&D expenditures or patenting, especially in the longer term. Some countries do provide empirical support for the traditional supply-led model of growth economics, that increases in technology lead to subsequent increases in output (GDP); but a larger number support the 'reverse causation' that output rises first, and some countries indeed show indications of both (suggesting a pattern of 'cumulative causation'). Conversely, cost-based supply factors like prices, wages and interest rates appear to have a rather limited impact on growth and capital formation, in contradiction with the EU's *Green Paper on Innovation* in 1995.

More specific country studies in the project, such as that for Poland in its transition decade of the 1990s, also find output change precedes technology performance; it also precedes changes in technology policy. The situation as regards the impact of macroeconomic policy is not however straightforward, because of the shift from 'soft budgets' to 'hard budgets' in the wake of transition. There is evidence that Central and East European (CEE) countries were carrying out 'too much' R&D before 1990 – at least too much of the 'wrong' kind – and our results would not support a return to this situation. On the other hand, we find macroeconomic policies since transition have tended to err of the side of being too restrictive, so far as allowing technological catching-up and expansion is concerned. The relationship between inflation and innovation, for one thing, appears to be non-linear: at first raising the rate of inflation promotes increased innovation, but beyond some point (though well above what the EU's stability policy would imply) further inflation reduces innovation. The change of external markets has also had an effect, at least over the 1990s, of cutting back demand for technology, at a time when more might have been valuable.

A major part of our analytical work has thus consisted of reassessing why this might be the case, of economic growth leading technological change (according to these indicators). Our enquiries have pursued two main analytical issues. The first is the aggregate relationship between macro-level demand and macro-level supply, which is reconsidered in paragraph 20 below. The second line of enquiry amounted to reassessing what can be termed the 'transmission mechanisms' whereby the additional demand gets converted into additional technology (supply). This takes us back into more meso-level and even micro-level considerations, which to some degree lay outside the scope of our project. Nevertheless, some substantial strides were taken towards establishing such pathways for transmitting demand-led impulses. One dimension of this involved the very different literature of 'innovation studies', which for many years has emphasised that the 'linear model' according to which science and technology created innovation, which then resulted in economic growth, is a gross over-simplification. Alongside such a supply-led model scholars in this tradition (and others) have developed demand-pull models, which see technology as resulting (in part) from a prior expansion of market demand, or 'coupling models' in which both mechanisms have a role to play. At the macro level, the 'reverse causation' pattern we observe can therefore be seen as an aggregation of demand-pull effects in individual markets. Some support for this is obtained in our econometric results on aggregate data.

In terms of such micro/meso 'transmission mechanisms', from a Schumpeterian perspective we can distinguish 'Schumpeter Mark I' firms and industries (typically SMEs swarming into new niches) from 'Schumpeter Mark II' firms and industries (typically large firms in established activities). Empirically European industries can be approximately separated into these two main groups, both of which are important for sectoral levels of innovation, though comparative advantages of countries are mainly determined by their structure of large firms and associated industries (Mark II). Aggregate demand factors may have an important 'pull' effect, especially on the setting up of SMEs in technologically advancing areas (Mark I). In more detailed data for the Netherlands, it appears that upgrading of skills occurs mostly through new entrant firms (see the work by the MERIT group, Partner no. 3). Another study for that country suggests that its large firms are more affected by (labour) cost factors and also international forces, whereas medium and smaller firms respond more to domestic fluctuations in policy. Generally, we would therefore conclude that micro-level activities are driven by specific conjunctures of supply and demand factors, among which need to be included aggregate supply (cost) and aggregate demand factors, i.e. the macro-level determinants.

Schumpeter's framework emphasises 'creative destruction' versus the alternative view of 'creative accumulation'. Schumpeter indeed envisaged the swarming of Mark I firms as the outcome of a creative destruction process, and this has been an important policy driver for supposed 'sunset industries' in recent decades. A contrary view is however that technological processes, especially, are cumulative rather than destructive. Science and technology are both 'path-dependent'. In assessing the impacts of 'technological natality' (the birth of 'new firms') and firm innovative persistence (the role of existing large firms), one of our studies concluded that for revealed technological advantage the latter Schumpeterian model of creative accumulation (the Mark II model) is the only significant process.

### 3. Skills, employment and technology – WP3

Another significant 'transmission mechanism' arises through skills, which we studied in detail in relation to employment in one of the Workpackages of the project. Most work by others here has focused on rising inequality through rising premia for skills in the latter part of the 20$^{th}$ century. The most popular explanation, especially in the USA, to explain the rising skill premium has been radical technological change, in particular the advent of the ICT 'revolution', which privileged computer literacy skills. This has however encountered several challenges. One is the 'Solow paradox', claiming that technological change was not very rapid in this era, because productivity growth slowed down. Another is the difficulty of reconciling this view with the acceleration of ICT diffusion in the 1990s coexisting with an ending of the trend to greater inequality (possibly labour supply by then had risen to meet the new demands, but why?). A third problem is the recent stress on 'skill-biased organizational change': that technological change had little impact without reorganization.

Our own explanation for the 'Solow paradox' rests on dissociating radical technological change from rapid productivity growth. On historical evidence we suggest that there is not a single skill premium, but rather a composite based partly on (usually very high) skills to create radical changes, partly on skills to produce those new technologies, and partly – increasingly over time – skills to use those new technologies. The two latter, and especially the user skills, show an inverse-U pattern, which accounts for the ending of the phase of increasing inequality, as the consequences of the radical changes diffuse widely to users without special aptitudes for utilising them (computers etc.).

An alternative method adopted by members of one of our partners was to recruit a model derived from new growth theory to account for the persistence of skill-based inequality. As explained above, this would require admitting 'exogenous' changes into the simple

model in order to get it to comply with real-world evidence. In this manner various assumptions were made in simulation of the model relating to hypothetical increases of skill supplies of various kinds, etc. This model underwent considerable refinement and extensions during the course of the project. It proved especially useful for analysing the potential impact of macroeconomic policy changes, on both demand and supply sides. One of the empirical applications to Dutch data showed there is a weak positive link between increasing skill intensity and innovation output, but however a weak negative link to process innovations alone.

Several of the partners in MACROTEC undertook studies of skill premia in CEE countries under transition, producing a great diversity of results. The overall picture indicated that a combination of catching-up plus trade specialisation (especially in regard to the quality of products traded) is required to understand the patterns of specialisation and wage catch-up emerging there. The industrial allocation of FDI and comparative educational attainment as well as the evolution of labour demand by skill groups all have some part to play. These studies yield an interesting (and at times unexpected) picture of the evolving division of labour in an Enlarged Europe. For example, a study for Hungary by Partner no. 6 establishes the primary role of labour demand in influencing skill premia, though a feedback effect through enrolment on labour supply can also be observed. The paper supports the 'skill-biased technological change' view, in seeing new technology and new capital (proxied by foreign ownership) as the main source of changing labour demand, but admits that direct evidence is hard to find. Several studies by our partners from Poland (partner no. 7) however are more sceptical of the labour demand approach, because of differences in the changes of skill premia between certain industries. In place of the 'skill-biased technological change' explanation they are more attracted to the rival trade-based explanation to account for rising inequality.

In employment and skill patterns, we thus again have to consider both the demand and supply sides of the issue in trying to account for change. We concur with the orthodox labour demand view as expressed in the concept of skill-biased technological change that the introduction of new technologies may induce a sharp rise in earnings inequality, although we see these relationships as altering and probably reversing over time. At the same time, we also show the need to take account of the labour supply side. This might include the effects of any rise in labour demand altering the conditions of labour supply (for example rising demand and growing wage premia for computer specialists giving rise to an increased supply of trained experts), although we expect that the lags here will be too long and possibly too variable to be verified through conventional econometric means. We also find some support for arguments about other influences on labour demand apart from technological change, such as the impact of (new) trade and FDI

flows. It seems likely that the causal patterns are to a degree all inter-connected, though in ways that are not yet much understood. Broaching the issue through a combination of approaches drawn from the Regulation school and from the National System of Innovation school offers some hope of a better future understanding.

### 4. Macroeconomic policy and technology policy – WP4

The MACROTEC project indicated in its original proposal that it would investigate a range of macroeconomic policies in terms of their impact on S&T, with a view to coming to some consensus about which policies or policy mixes were most suitable for supporting S&T. At its simplest, this was envisaged as coming down to a choice between macroeconomic policies directed mainly at the supply side as compared with those directed mainly at the demand side. In the second half of the 20$^{th}$ century, and especially in its final quarter, the choice between supply-oriented and demand-oriented macroeconomic policies turned into acute and often bitter conflict, not just among theoreticians but more broadly across the scene of practical policy-making. The primacy of aggregate supply over aggregate demand is reflected in the macroeconomic policies of the EU and especially in the 'Maastricht criteria' for joining the EMU.

Envisaging the matter as a question of governments having sufficient 'instruments' to meet such 'targets' as economic growth, full employment, price stability, balance of payments and so on, we find that governments during the period of the supremacy of aggregate supply ('supply-side economics') have severely restricted the choice of instruments from which to choose. As a result they have found it difficult to attain simultaneously the range of targets they might have set themselves. Fiscal policy as an active ingredient was largely abandoned because of the argument sketched out in WP2 above, that increased aggregated demand would lead to inflation without any permanent effects on real output (save in correcting severe disequilibrium). Monetary policy came to be the main weapon of governments' macroeconomic policy-making, and via interest rates was mainly directed at price stability, with full employment and economic growth being sacrificed where necessary to meet the target of low or zero inflation. The main instrument for attaining growth (and other targets) instead came to fall in many countries (not least the CEE countries under transition) on privatization which, even where successful, by definition was a once-for-all impact and removed the areas involved from the ambit of subsequent governmental concern. Our empirical studies of the evolution of government policy in the variety of countries embraced by the project show a number of common themes relation to the underlying stance of macroeconomic policy-making. The general pattern has involved some sharp shifts of direction as between Keynesian and 'Ricardian' stances, but we find little indication of any commitment to

what we would term a Schumpeterian stance. The same shifts have occurred even more abruptly in the CEE countries since 1990, but again with no evidence of the emergence of the kind of Schumpeterian framework which we believe is called for.

The 'orthodox' view that has prevailed in economics since the 1970s is that boosting aggregate demand can have only short-term effects of recovering from disequilibrium. A rise in the aggregate demand curve initially results in an increase in real output but also some increase in inflation. This however rests upon workers being tricked into accepting real wage cuts because of the extra inflation – when these are restored the increase in real output vanishes and all that is left is the extra inflation. In the 'rational expectations' version of this argument, the aggregate supply curve is vertical, as workers refuse to be tricked at all, and there is not even a short-run increase in real output. However these models make a number of strong assumptions, including the absence of any impact of the shift in the aggregate demand curve on the aggregate supply curve. Our empirical results instead show that a rise in output leads to a rise in technology, i.e. an outward shift of the aggregate supply curve. In these circumstances, the rise in output from increasing aggregate demand will be larger than where the aggregate supply curve is taken to be fixed, and the additional inflation will be smaller (it may even disappear). Moreover, these results hold good even under the rather implausible theoretical assumption of 'rational expectations'. Consequently much of the project turned into reassessing the role of aggregate demand for technological change and hence aggregate supply, as its primary policy focus.

While the EU's Stability and Growth Pact tends to assume the rate of inflation should be close to zero, there is in fact little evidence that moderate inflation is deleterious and may indeed be beneficial on balance. This proposition was formally established in a papers by partners of the project, and is supported independently by work in North America and surveys by OECD economists. We find that the relationship between inflation and technology is likely to be characterised by an inverse-U shaped curve, with the maximum impact on technology being attained at a level of inflation that is substantially higher than imposed by the Maastricht criteria.

What we are therefore putting forward is a compound of old Keynesian views about expanding aggregate demand with newer Schumpeterian views about the role of technology. This is *not* in contradiction to supply-side, monetarist views about macroeconomic theory, indeed it incorporates such views. Both Keynes and Schumpeter, after all, placed great emphasis on reasonable price stability. What it does contradict is the inferences about macroeconomic *policy* which are embedded in current EU stances. It is saying that in anything other than a very short-term view, current economic policy

prescriptions may be inconsistent with the other main EU objective of promoting the competitiveness of the EU economy.

It has to be accepted that a significant part of this hybrid Keynesian-Schumpeterian approach remains underdeveloped as yet, especially where it has to do with an 'open economy' version of such a model. The prevailing post-Keynesian view on the open economy relies on export-led growth, but has little to say about the current importance of international flows of factors (e.g. FDI) or flexible exchange rates. The prevailing 'Schumpeterian' view about technology in an open economy is the so-called 'technology gap' approach, that differences in international trade performance across countries can be accounted for by differences in technology levels (the 'gap'), but in writings to date the technology gaps are often taken as givens. As such, this does not represent a huge advance on supposing technology to be exogenous. We can, however, expand the horizon by envisaging technology levels (and concomitant organizational levels) to reflect differences in national technology systems, differences in technological 'regimes', and differences in national or supranational economic policies. That way, they can be 'endogenised' in a broader setting.

We need also to understand the transmission mechanisms underpinning the use of fiscal policy etc. to enhance technological performance and policy. Some of those operating at a micro level are noted in WP2 and at a meso level in WP3. Here we consider more macro-level transmission. Complementarities between the public and private sectors within the national system in terms of conducting R&D may constitute one such macro mechanism. The monetarist conception of R&D expenditure in this light parallels its view of other productive activities – that expenditure by the public sector 'crowds out' expenditure by the private sector, and as the latter has a higher level of business acumen, the former should wither away. Over time, however, our cross-country studies of all the OECD countries for which we have acceptable data show few instances of countries in which any 'crowding out' appeared to occur as between public and private sectors in R&D, whether viewed from the side of funding or from that of performing R&D. Our own findings are supported in more general overviews. In terms of the 'Barcelona target', this suggests that there could be complementarity between any expansion of public R&D and the desire to raise private R&D, though the target more often expresses an implicit substitution between the two. We would counsel a 'national system of innovation' viewpoint, according to which there should be an integration of public and private RTD activities, and we contend that this is the practice followed in the USA, contrary to much popular opinion.

Taking an 'open economy' standpoint, the accumulation of technology within a country leads to the attainment of the country's technological profile, and hence its technology gaps compared with other countries. The international dimension thus provides a further macro-level transmission mechanism. The basis of comparative advantage is increasingly being defined by imported rather than domestically generated technology in the 'cohesion countries' like Spain and Greece, and in the transition countries since the early/mid 1990s. We also observe that unless this FDI is intertwined with domestic capabilities the countries concerned will continue to be vulnerable; so, for instance, our studies show that Greece for too long relied on technology transfer at the expense of technology creation. A key issue is that FDI is being largely treated as a substitute for indigenous (domestic) technological capability rather than its complement, e.g. in Poland where domestic capabilities in many areas seem to have reached the point of exhaustion. In Bulgaria, we have some evidence that the macroeconomic policy of currency stability since 1997 has encouraged some growth in inward FDI but been associated with further declines in the country's own business-funded R&D. The emerging 'assimilationist' view of technological advance in catching-up countries emphasises that there have to be active domestic responses to FDI, in entrepreneurship, labour markets, and institutional arrangements, as the case of Ireland positively demonstrated. Relying on 'embodying' technology through raising FDI is not sufficient.

Our studies of Greece indicate that more purposive use of the Structural Funds was probably more central to turning around the domestic economy than the conventional macroeconomic gains from its accession to the EU. At present, the use of the Structural Funds for innovation purposes as opposed to reducing regional inequalities remains somewhat inconsistent and indeed often controversial. What we can readily observe from both theoretical and empirical evidence is that rising inequalities and labour market hysteresis can have deleterious effects on aggregate demand and hence on the demand-pull incentive to innovation. Fiscal policies may have to be designed to offset the more negative impacts of monetary and related policies on the innovation process.

Changing policies involves much more than reallocating governmental effort – to be effective the underlying institutions need to be transformed. The 'transition' process in the CEE countries exemplifies this in an especially stark manner. The national systems of innovation of the socialist era with their attendant networks have largely imploded, leaving a near-vacuum. Global systems have eclipsed national systems as avenues for technology generation. The superiority of western technology, brought in through inward FDI, has swept all before it as a means for technology transfer. In our view it is crucially important to re-engage with internal sources of technology generation and adaptation. Naturally this does not mean going back to the discredited systems of the socialist era,

but for the long-term viability of the national systems in the transition countries there needs to be a reconnection of this kind, otherwise the benefits from FDI may turn out to be once-for-all and bounded rather than acting as a spur to continuing expansion. It is crucial to shore up the national 'absorptive capacity' – market forces alone will not be able to do this.

### 5. The impact of supranational macroeconomic policies – WP5

The results developed in WP4 carry implications for policy-making by the European Commission. An obvious one is that policies aimed at supranational macroeconomic stability through meeting the Maastricht criteria, emphasising the supply side, could have unintended negative consequences on the demand side for technological progress and hence growth. This may have deleterious effects on the accession countries as they aim to meet the acquis for the accession process, an outcome which already seems to have appeared in Poland. On the other hand, the consonance between output growth (as the driver) and productivity growth is more pronounced in the medium term, while that between output growth and technological change is ambivalent in the short run and probably strongest in the long run. Thus if the stabilisation policy does achieve its object of permitting controlled expansion thereafter, its effects could turn very positive. Secondly, the introduction of 'open methods of coordination' as an EU strategy may permit greater sensitivity of response at the level of the individual 'national system of innovation'. The very variety of those national systems as underpinned by our research indicates the importance of this consideration. Thirdly, as the study of Greece shows, one should not forget the potentially galvanising effect of inflows of EU funding for inducing local technical change.

Overall, our specific findings confirm our presupposition that macroeconomic policies and S&T policies are too disarticulated across the countries we survey, and there is a need – most powerfully in the catching-up countries – for much greater coordination between them. We find that raising intangible capital intensity, through R&D, human capital formation, etc., does have positive effects on growth, as the conventional argument maintains, but that the payoff may be rather disappointing relative to expectations in the short to medium term. Shifting course to a new technological paradigm such as the 'knowledge-driven economy' may be expensive in the medium term, and governments need to look further into the long term for sustained gains. It is understandable that the development of supportive policy instruments at macro and micro levels may become frustrated by the slowness of the process, but the necessity for them nevertheless remains, as the alternatives appear far worse.

## 6. Conclusions

There was an impressive convergence of views about policy implications in the course of the MACROTEC project. The most evident case of this convergence relates to the switch of emphasis from the supply side to the demand side. This is demonstrated both in the policy sphere and in analytical terms. Our analytical work, as highlighted previously, aims to gives equal weight to views that pay attention to the demand-side causes of growth, or often both sides. In this format, technical progress is endogenised as a response to the growth of output or as a feedback from it, representing a leap beyond the partial endogenisation of the 'new growth theory'.

In policy terms, there are a number of ways in which we might expect to see macroeconomic policy helping to drive (or obstruct) technical progress, and hence the active effects of S&T policies. The orthodox supply-driven approach looks at the role of costs and prices, and this has been the primary channel of impact entertained by governments of EU Member states since the 1970s. The lowering of unit labour costs for either unskilled or skilled workers may be expected to increase profitability, and more widely competitiveness in international trade. However it may act as a disincentive to labour-saving technical change, and hence to industrial 'upgrading'. Further consideration of the effects operating through skilled labour were pursued in WP3. Alternatively, reduced costs may affect the cost of capital, either tangible or intangible. Our work does suggest that there may be some negative relationship between the real rate of interest, as a rough measure of the cost of capital, and the relative decline of physical capital investment since the 1970s. However this also implies an unexpected positive relationship with the relative rise of R&D (intangible investment) over the same period, contrary to supply-side predictions. More detailed study of cost factors in the CEE countries suggests that the best outcome appears to be an 'accommodative' macroeconomic regime, as a compromise between economic stability and the need for industrial transformation.

Through the overall impact on prices, inflation has been widely seen as a deterrent to growth in the advanced industrial countries since the Second World War. It is widely accepted that too high a rate of inflation will reduce and perhaps destroy the incentive to innovate. The more controversial issue is what happens with regard to low rates of inflation. Here, our studies at both theoretical and empirical levels have suggested that some positive rate of inflation may be beneficial for technology. Our empirical findings indicate that the rate of inflation at which technological change is maximised may be higher than often thought, which in turn suggests that the Maastricht criterion of

targeting a zero rate of inflation is almost certainly too restrictive. This opens the door to more expansionist fiscal and other policies.

Our principal new findings therefore relate to the increased attention we have paid to demand-side influences. The findings are very consistent across countries and levels of aggregation, though they are – like the effects of inflation – by no means clearly understood. In country after country we find that aggregate demand impacts on technology are at least as powerful as the orthodox converse relationship, and this shows up as well in our econometric work using cross-country data. We have indicated potential 'transmission mechanisms' that operate at the micro level of new firm formation occasioned by increased demand, at the meso level of the rise of new industries (like ICTs) and the implications thereof for skill formation, and at the macro level of public/private sector RTD interaction and institutional change. We have outlined a simple extension of the orthodox model of aggregate demand and aggregate supply whereby increases in the former can have sustained effects on raising the latter, via the inducements to technology from the increased demand, contrary to received views.

Equally, traditional Keynesian policies of boosting demand through budgetary expansion are of limited use unless they can be oriented to productive purposes, as Keynes himself well recognised. Fiscal expansion for its own sake is not exonerated in our analyses. For the case of Greece, macroeconomic policies were often 'inappropriate' for their economic context, e.g. through being expansionist when the country could not afford it, or being unduly austere when growth was urgently needed, and probably had little positive impact on S&T. The era of 'hard budgets' in Poland has been more successful than pre-transition days of 'soft budgets'. What is needed is not a crude Keynesian apparatus but a new hybrid of Keynesian and Schumpeterian policies in order to call forth the interdependencies between supply and demand.

These results carry strong implications for policy-making by the European Commission, as outlined in paragraph 28 above. Our perspective on the Barcelona target of raising EU R&D intensity to around 3%, with two-thirds to come from private sources, is very much framed by these considerations of complementarity. As neo-Schumpeterians, we have a prior sympathy for aiming at such a target. However we also consider that its benefits will be greatly reduced, and the target itself probably become unattainable, unless due attention is given to the complementarities we have been describing, particularly those between aggregate demand and aggregate supply.

The emphasis lies on such complementarities. We would stress that our approach throughout would be one of 'and' rather than 'or' – one of promoting complementarities

rather than replacing with substitutes. Thus we have indicated how in analytical terms an aggregate demand strategy can itself impact upon aggregate supply and thereby generate real gains in technological accumulation for the growth of economies. At the same time we consider that aggregate supply policies have a role to play. We have focused mainly on fiscal rather than monetary policies as the means towards proactive aggregate demand strategies, not least because under EMU individual nations largely abandon any possibility for pursuing distinctive monetary policies, but there is some scope for differences in budgetary policies.

We consistently find substantial effects from externally oriented national policies, in regard to both trade and FDI. These appear to be most pronounced for catching-up or 'intermediate' countries. The relationships between technology and these external policies appear to run in both directions, from technology to trade and vice versa. Our principal finding is however that external impacts depend upon internal activities, in particular the need to generate 'absorptive capacity' to take advantage of any favourable external conditions. Much of our study has therefore been directed at 'open economy' versions of the putative Schumpeterian model for macroeconomic policy, an area which we consider particularly underdeveloped in the theoretical literature. The general presumption is that accession will lead to a rise in FDI into the accession countries; such FDI will embody new technologies and new business practices, which in themselves help advance the host countries. The main issue, though, is whether such FDI and the embodied technologies and skills are complements to or substitutes for indigenous technologies and skills in these host countries; the bulk of our evidence for the transition countries to date unfortunately suggests mainly the latter. We see this as a serious threat to the long-run viability of the transition economies. The national innovation systems of the countries need rebuilding, especially in the direction of realigning them with supranational and global systems, in order for the benefits of FDI to be fully realised. In no way is this a zero-sum game: interacting with improved domestic resources could easily enhance the returns obtained by multinational companies. But a new public-private interaction needs to be forged.

## II. BACKGROUND AND OBJECTIVES OF THE PROJECT

### 1. Rationale for the project

A common thread in macro policy-making in Europe, at both the national and the supranational levels, is to maintain a rather rigid distinction between macro-economic policy on the one hand and macro-level technology policy on the other. The cardinal example of this is the European Commission, for which these two areas constitute its main policy-making focus. On the one side is the formulation of EU economic policy, couched in terms of the Growth and Stability Pact, on the other side is EU technology policy, spearheaded by the Framework Programmes. The key issue that has been considered in the MACROTEC project is the lack of interconnection between these two great fields for policy, not just in the EU but in the several countries which constitute it (and indeed in the great majority of countries today, including those aspiring to accede to the EU).

### 2. Original objectives

The broad objectives were set out in the original Work Programme, as follows:

"Our primary scientific objective is to pursue analytically the effects of macroeconomic change on technological change and to derive implications for policy. To do this, we would need to reassess the determinants of technical change as they arise out of changes in aggregate demand and supply. We plan to do this by a combination of empirical studies of the observed relationships between changes in macroeconomic policy and outcomes for S&T development and theoretical analyses of the determinants of technical change.

"The analysis would consider the interaction of these two policy areas according to individual and diverse country experiences. In particular, the aims of the project are:

- To investigate to what extent macroeconomic and S&T policies in several European countries are mutually compatible. The project would aim to produce a more substantial and adequate check-list of relationships between macroeconomic policy and technical change which should be useful for consideration in any discussion of national and international policy-making.

- To assess how compatibilities and incompatibilities between macroeconomic and S&T policies affect employment, growth and technical change in selected European countries.

- And to suggest new policy approaches and policy mixes which should integrate macroeconomic and S&T policy in order to promote structural change."

### 3. Reorientation during the project

By and large the above continued to guide the project throughout its two years of existence (which, with the permission of DG Research, was slightly extended). The main change was that the outcomes proved to be more radical than originally expected. As a consequence, the detailing of individual policy mixes of the kind noted above came to take second place to the larger policy issue of integrating macroeconomic with S&T policy as a whole, in line with the underlying rationale. This is what we concluded by describing as a call for a new 'Schumpeterian macroeconomics', an objective not envisaged at the outset of the project. Moreover, external considerations relating to developments in EU policy, particularly the setting of the 'Barcelona target' for raising EU R&D intensity, came to the forefront in relation to our policy advice, and the directions of investigation as well as the outputs and dissemination had to be remodelled accordingly.

The more limited consideration that was thus given to specific policy choices reflected the limited time set for the project. This included the exploration of specific EU policies. e were compelled to move away from the original plan of a 'checklist' as we began to comprehend the fundamental nature of the disconnectedness of aggregate policy-making. The other uncompleted task was the finalization of a comprehensive and compatible database, although as noted below considerable strides were taken in this direction, notably for the accession countries. With hindsight, a 3-year rather than a 2-year research programme would have been needed to complete the tasks originally set.

## III. SCIENTIFIC DESCRIPTION OF PROJECT RESULTS AND METHODOLOGY

### 1. Theoretical framework: WP 1 (literature survey and analysis)

The largest proportion of the written output of MACROTEC in Year 1 was devoted to WP1, as was originally envisaged. This was partly because the theoretical and analytical approaches hitherto used towards our subject were diverse and partial, and also because, like many such investigations, we needed a closer and better structured acquaintance with relevant empirical work. The most visible form of our output consisted of the document prepared at BETA (Partner no. 10) for distribution at the Vienna meeting, edited further at SPRU for the Athens meeting. Presentations on the document were made at both meetings by way of outlining the broad analytical directions of the project.

There is only brief space here to relate the main findings (the working draft paper from BETA alone runs to 86 pages). The survey here covers: a) the theoretical, empirical and policy literature reviewed in this survey; b) other recent research of similar kind; c) other work relevant to WP1 that has emerged from other partners in MACROTEC. We then proceed to synthesise views from MACROTEC concerning the existing literature relevant to our subject matter, though the conclusions require linking these views to our own theoretical developments discussed in relation to WP2 below.

#### 1.1. The literature review

In accord with orthodox economists' approaches, the survey from BETA begins with the 'simple' neoclassical (Solow) supply-driven model of growth in which technological change is the main driver of growth but is exogenously determined. Its limitations on both empirical and theoretical grounds have led in recent times to 'new growth' models in which technology is (partially) endogenised. These are discussed in both one-sector and two-sector forms, along with associated empirical studies and limitations. The survey then turns in less orthodox fashion to the impact of macroeconomic policies and the role of the state. In relation to long-run growth, these are divided into: i) short-term disequilibrium (e.g. inflation, unemployment, macroeconomic volatility); ii) 'structural dysfunctioning' (e.g. inequalities, labour market hysteresis, uncertainty); and iii) trade orientation (e.g. trade, economic integration). The survey then departs substantially from orthodox economists' approaches to consider alternative ways of taking account of macro perspectives on technological progress. The four principal alternatives surveyed are: i) Neo-Kaldorian views about 'cumulative growth', where growth is more demand-driven and the aim is to be compatible with Kaldor's 'stylised facts' about economies in the long

term; ii) Regulation school views about regimes of accumulation and differences between countries in modes of 'regulation'; iii) National Systems of Innovation views, widening into interpretations of 'social systems of innovation'; and iv) Neo-Schumpeterian approaches based on evolutionary growth models, drawn from both micro and macro foundations.

While nearly all of the constituents of these varied approaches are now in place, further work is still required on linking their diverse perspectives into a more satisfactory overview. The outcomes mostly support our prior anticipations, but with at least one important qualification. This qualification is that the amount of work, both theoretical and empirical, which is relevant to our subject is substantially larger than originally allowed for. This is in line with the views of at least one referee of our grant application. What this has meant for us is that the quantity of work devoted to preparing the documentation for WP1 was more extensive than expected, and the scale of the output already much larger than anticipated, which partly accounts for the length of the BETA document. However the document by implication established that we were right to think that most of the work done to date was only indirectly connectible to our key objectives, and that in that body of literature itself there were few attempts to conduct 'joined-up thinking'. Most of this very large but very diverse literature pursued its own habits of thought and 'paths of least resistance' irrespective of the practical policy relevance or implications.

A paper by Le Bas from Lyon (Partner no. 2) conducts more detailed investigation of the pathways (later referred to below as 'transmission mechanisms') whereby demand-pull factors may intensify innovation. Le Bas considers a range of less well-considered aspects, such as the role of the business cycle, the effect on new firm formation, and the effect on appropriability strategies (property rights), in addition to the better-known 'Schmooklerian' ones. His survey looks more deeply into the characteristics of actual 'knowledge spillovers', and ends with discussing the interaction between supply-push and demand-pull factors. The essence of this contribution was included in the BETA paper described above.

A paper by Brzozowski assesses the theoretical importance of inflation in explaining the market share of technologically new or improved products. To that end he adopts the mechanism explored in the literature on the role of price signals in a world of imperfect information. Since inflation generates larger variation in relative prices, it limits the amount of information about product quality otherwise transferred via the price. As a result consumers do not necessarily infer high quality from the high price, and the market share of a new product of unknown quality shrinks. However, as inflation

accelerates, consumers become more willing to gather information on price movements in individual markets and can correctly identify a high-quality product observing its price. Thus, once the inflation rate reaches a threshold, a high price regains its attribute of reflecting a high-quality product. This forms a component of his finding that inflation may have inverse U-shaped impacts on technology and growth, and that zero inflation is not necessarily ideal

A second paper by Brzozowski develops this point in emphasising the role played by macroeconomic stability in the process of adoption of new technologies, in the light of two differing models. The first model, for a closed economy, can be applied to advanced countries with a well-developed own R&D sector. Its main findings are that firms are less apt to adopt new technologies in the face of inflation and they demand innovations of bigger size. The second model, for an open economy, is constructed to describe the situation of less developed countries absorbing a new technology from abroad. In that context exchange rate instability seems to be the major force influencing the rate of technological progress.

### 1.2. Recent survey research by others

In the course of Year 1 of MACROTEC, two important surveys issued from the OECD which covered somewhat similar ground to our own survey. On the one hand this established the fact that policy-makers were urgently in need of surveys of this sort of material. It is worth pointing out that both surveys: S. Ahn & P. Hemmings, 'Policy influences on economic growth in OECD countries: an evaluation of the evidence' (OECD Economics Dept, Working paper 246, June 2000); and A. Bassanini, S. Scarpetta & P. Hemmings, 'Economic growth: the role of policies and institutions; panel data evidence from OECD countries' (OECD Economics Dept, Working paper 283, Jan. 2001), were of similar length to our own survey. The former ran to 102 pages and the latter to 68 pages, proving that it is not possible to draft an adequate survey of this disparate field in a short document.

On the other hand, the papers do not span the field that we have found it necessary to cover. Though excellent surveys of their kind, they take a fairly orthodox, supply-driven approach to the relationship between resource growth, economic growth and policy. This is a view we would question on the basis of both our theoretical survey, which is more heavily weighted towards demand-driven models of growth, and our empirical research, which places particular emphasis on the feedback effects of economic growth on policy. Secondly, and more obviously, the OECD authors devote only limited attention to issues of science and technology, though they do more on this subject in their second paper.

1) Again there is only limited space to discuss their findings. In the theoretical/empirical survey, the authors stress that the selection of countries is critical, and well-known findings from multi-country studies frequently become statistically insignificant when limited just to OECD countries, implying that they are coarse-grained in nature and of limited relevance for fine-tuning policy.

2) Their survey of the role of macroeconomic policy presents the general view that greater policy stability has produced "an environment more conducive to economic growth in the longer-run" (p 32). The empirical evidence strongly supports the damaging effects of hyper-inflation, but as they state is more mixed about moderate instability. This is much the same as we find (see below). They point out that different sources of volatility (e.g. monetary policy vs. fiscal policy) may have different impacts.

3) There is more consistent evidence of a positive impact from trade growth and trade policy on economic growth, though some well-known papers have found the reverse. Measures of trade policy are however often to our eyes superficial (e.g. 'openness', i.e. exports plus imports), technological conditions are usually asserted rather than measured (compared for instance to the 'technology gap' literature which these authors fail to include), and - as they do state - the line of causation is unclear.

4) There is still much indecision about the contribution of R&D to economic growth and to the role of 'knowledge spillovers', not least because of measurement problems. The extent of 'crowding out' between public and private R&D is also controversial.

5) Most studies show a strong positive correlation between education and economic growth, but the precise sources and causal mechanisms are unclear, for example which is cause and which is effect. Also unclear is the role of policy in advancing education, as compared with private and other motivations to do so. The coarse-grained nature of the results is particularly apparent here.

6) More attention should perhaps be given to the contribution of 'social capital', though its definition is currently somewhat ambiguous, and the most appropriate policy measures to raise social capital have yet to be well established.

The second paper contains a larger proportion of the authors' own research, though it begins with a quite extensive survey of previous results, which however concentrates

almost exclusively on neoclassical findings and ignores most of the work on which we build in our project. The econometric estimation from a panel-data perspective incorporates both short-run and long-run behaviours, as in our own work discussed below, but through the somewhat different technique of 'Pooled Mean Groups'. Growth is assumed to be entirely supply-driven, following the conventional neoclassical (Solow or endogenous growth) view. The growth equations are estimated for 21 OECD countries 1971/98, and are thus comparable with many of our own estimates noted below. The results do not seem to support some endogenous-growth or conventional neoclassical growth models. More novel are the findings in relation to macro policy variables. Inflation variability is negatively related to growth, but the effect of the level of inflation is less consistent. To assess the role of the government, the authors stress the need to consider both the tax and the expenditure side of the government budget. The impact of government, positive or negative, depends on the particular assumptions made (including the possibility of 'reverse causation'). The authors depart from some earlier findings in establishing a strong contribution from education (social returns exceeding private returns). R&D appears to have a positive impact on growth, as would be expected, though there is some doubt over the contribution of public R&D. Increased exposure to trade raises output per capita, again as expected. In our view, this useful survey needs to be broadened to cover more demand-oriented and non-neoclassical views about growth.

### 1.3. Limitations of current analyses of economic growth

We now cover the analytical conclusions of the MACROTEC project. Views of economic growth theorists have broadened in recent decades. The traditional neoclassical view as expressed in early work by Solow (1957) and others used the notion of a production function, relating levels of output to differing combinations of levels of input, to derive the rate of economic growth. The latter was fixed primarily by the rate of technical progress, which was exogenous to the production function. Empirical studies using this derivation found consistently that the exogenous rate of technical progress (measured by the growth of Total Factor Productivity, TFP) explained the majority of long-term growth of industrial economies, which as Solow himself admitted left that growth rate as effectively unexplained. Later estimates reduced this 'residual' by adjusting for the quality of inputs, but this may have masked some of the impact of technological change. The smaller part that was explained was given by rising capital intensity, and according to our empirical data outlined below that at least served some purpose in the 1950s and 60s when such theory was evolved, since this was an era in which a rising share of total output was going into capital formation.

From the 1970s onward, the empirical case for adopting this line of approach weakened. First, the rate of growth of total output, and with it the growth of TFP, became slower and more erratic. Second, capital formation as a proportion of total output ceased rising and began trending downwards. Third, technological progress shifted towards more radical change, demonstrated in ICTs, biotechnology, etc. The conjunction of the first and third of these gave rise to the 'Solow paradox', that radical technical change was not mirrored in the productivity statistics. However this is only a paradox if one equates TFP with technology, which (for reasons spelled out more fully below) we would argue is not the case in the longer term.

Dissatisfaction with the explanatory power of the Solow model accordingly led theorists to rethink the role of 'technology'. The concept of the endogenous element of 'capital' was broadened to embrace not just tangible physical capital (plant and equipment etc.) but 'human capital' in the form of a stock of skills and 'intangible capital' especially in the form of R&D. According to the so-called 'new growth' theory (e.g. Romer, 1986; Lucas, 1988; Aghion & Howitt, 1998), increases in either of the latter could also raise the rate of economic growth. Even if R&D is carried out in private companies which obtain private returns from their R&D expenditure, it can still generate some increasing returns through 'spillover' effects from the new information which benefit others (Romer, 1990). In effect, there were claimed to be constant or even increasing returns from expanding 'broad capital' (i.e. tangible plus intangible plus human). This can be regarded as the theoretical counterpart of the EU's 'Barcelona target' – raising the intensity of aggregate R&D from around 2% to around 3% of GDP should have sizeable impacts on rates of growth in the European economy, currently projected to increase by around 14% from such an expansion. Certainly the extended emphasis on R&D and on human capital appeared to suit the new realities of the 'knowledge economy' since the 1970s.

However the 'new growth' approach faces problems of its own, both empirically and theoretically. On empirical grounds, Charles Jones (1995) found that higher rates of R&D spending in 7 leading OECD countries in the latter part of the 20$^{th}$ century were not associated with faster rates of growth; he therefore restated the more traditional view of diminishing returns to raising R&D expenditure. Our own empirical findings, based on a much larger sample of 23 OECD countries over a longer period of time, confirm this result (von Tunzelmann & Efendioglu, 2001). In terms of patterns over time, there was a sustained increase of R&D intensity in OECD countries, mainly between the late 1970s and late 1980s. In our view this reflects to a considerable degree the rising cost of developing ICTs over these years (von Tunzelmann, 2000). There was no immediate payoff in terms of growth – the 'Solow paradox' in that sense prevailed. On a cross-country basis, the European countries with higher levels of R&D intensity were also, on

average, those with slower rates of growth. This, too, can be explained as 'diminishing returns' – as countries reach higher and higher levels of per capita income, the costs of developing new technologies also rise, as they in effect approach the world technological frontier. These costs have to be borne as the 'price' paid for ever higher levels of income – the price is that the growth rate will slow down, other things being equal. On these grounds the payoff in growth to actually attaining the Barcelona target could be much less than is being hoped for. This does not mean that it will not have any effect – it will still have some positive impact unless diminishing returns become so great as to be 'immiserising', which seems rather unlikely. However the 'constant returns' or 'increasing returns' propositions seem equally unlikely as a basis for forecasting. To be fair, the European Commission is not expecting anything like such a proportionate increase.

On theoretical grounds, other difficulties however arise with the optimistic 'new growth' scenario. First, the notion that (private and public) R&D generates 'spillovers' that are freely available for others to capture is an unduly generous one. Most technological progress is based on knowledge rather than on information, and spillovers require an associated development of the knowledge base. Thus capturing spillovers even by way of 'imitation' is far from costless, and empirical evidence supports this. We come back to this in discussing systems of innovation below.

Second, the issue of where the new expenditures on 'broad capital' come from is effectively still exogenous in the 'new growth' perspective. Although various categories of such expenditure are indeed assessed for their impact on growth rates, their source remains something of a mystery. The approach is still predominantly a neoclassical one, even though its adherents regard themselves as 'neo-Schumpeterians' (with some justification). It is neoclassical in the sense of being supply-led: should the supply of components of broad capital expand – for example should R&D spending rise in line with the Barcelona target – then more growth will ensue. From an innovation studies perspective this however is difficult to accept unreservedly. In that very different approach, the crude 'linear model' whereby greater science generates greater innovation and ultimately greater output has long been discredited. Instead, technology is seen to be the outcome of 'demand-pull' as well as 'supply-push' factors (e.g. Freeman & Soete, 1997). The evidence has been extensively assessed; we return to the point below but all that needs to be said here is that there is convincing support for the view that both mechanisms play a part in determining the rate of technological progress, though they may operate in varying proportions at different stages of technology lifecycles and indeed at different points of historical time (this is Freeman's 'coupling model'). It seems likely that pure supply-push, e.g. ex-ante increases of R&D expenditures, will indeed generate

sharply diminishing returns *unless* matched by corresponding (perhaps ex-post) increases of demand for that new technology.

Thus scholars have drawn attention to the role of rising educational expenditures as a supply-push element in 'new growth' vein to account for the sustained growth of the European economy in the 1950s and 60s (Crafts & Toniolo, 1996), but it may be equally valid to see the rising educational levels as the *consequence* of a sustained growth of demand for skills. In other words, the new growth theory has 'endogenised' the growth itself, but it has not succeeded in properly endogenising the constituents of 'broad capital', including technology, which are still seen as basically exogenous drivers of growth from the supply side. This is mirrored in the view of theorists such as Lucas (2003) that demand can contribute vastly less than supply to longer-term growth, essentially because demand increase is seen as once-for-all in nature.

## 2. Macroeconomics and technology performance: WP 2

The Work Programme for MACROTEC specified the objectives and methodology of WP2 as follows.

*Objectives*: To examine the relationships between macroeconomic performance and technological change, using quantitative studies of individual countries and events together with cross-country comparisons.

*Methodology*: This would involve specific country studies of a) the relationship between cost structures and S&T indicators; b) the relationship between aggregate demand and the demand for technology; c) the relationship between economic stability and S&T success. Special attention will be paid to the accession countries, and there would also be panel-data analyses of cross-country experience.

### 2.1. Datasets

Another major part of the first year's output from MACROTEC, aside from the theoretical framework, consisted of the development of databases on macroeconomic variables and on technological variables, intended for the pursuit not only of nationally based studies but especially of cross-country studies. There are however extreme difficulties in squaring the data on many of these variables across countries, so we were forced to rely to a considerable extent on OECD and similar data to get as close as possible to cross-country compatibility. In addition, it proved necessary to research and sometimes re-estimate data for Central and Eastern European countries (CEECs), in view of the unreliability of some of the published data.

### 2.1.1. Cross-Country macro data

Aggregate Country-Level Data (collected mainly by Pari Patel in Partner no. 1): the main effort was concentrated on collecting indicators for macroeconomic performance and technology performance. This has resulted in the following sets of data:

**Table 1.** Data provided on the website

| Time Period | Variables |
|---|---|
| 1989-2000 | GDP in current prices, constant price indices and average percentage change |
| 1990-2000 | Composition of final demand (per cent of GDP in current prices): consumption, investment, and trade |
| 1991-2000 | Growth of various components of final demand (annual percentage change from constant price data): consumption, investment, government and trade |
| 1993-2000 | Contribution to final demand (from constant price data): consumption, investment and trade. |
| 1990-2000 | GDP by sectors, volume indices; 1993=100 |
| 1989-1999 | Investment by economic sectors, current prices, values and shares |
| 1990-2000 | Per cent of total sectors' value-added, current prices |
| 1989-2000 | Total industrial output volume indices (1989=100) and annual percentage changes |
| 1989-2000 | Industrial output by NACE, indices, previous year=100 |
| 1989-2000 | Retail trade (percentage change over same period of previous year) |
| 1989-2000 | Total employment and unemployment; employment in industry; and total population: indices (1989=100) and levels |
| 1989-2000 | Gross and net wages for total economy and industry |
| 1994-2000 | Real gross and net wages (percentage change) |
| 1990-2000 | Productivity in industry (percentage change); unit labour costs in industry; real unit labour costs in industry |
| 1993-2000 | M1 (annual change and percentage of GDP); broad money (annual change and percentage of GDP); total credit (annual change and percentage of GDP) |
| 1989-2000 | Consumer price index and producer price index |
| 1993-2000 | Short-term credits and deposits; average yield on short-term govt. securities, annual average (annual average) |
| 1995-1999 | Government revenue and expenditure as percentage of GDP |
| 1990-2000 | Annual average exchange rates (national currency to US dollar) |

| | |
|---|---|
| 1990-2000 | Current account balance and FDI inflows (million US dollars) |
| 1989-2000 | Imports and exports in US dollars |
| 1996-2000 | Changes in commodity composition of foreign trade |

**OECD Countries**

Countries Included: Australia, Austria, Belgium, Canada, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Japan, Korea, Luxembourg, Mexico, Netherlands, New Zealand, Norway, Poland, Portugal, Spain, Sweden, Switzerland, Turkey, United Kingdom, United States.

Time Period: 1981-1998

Variables: R&D Expenditures and Personnel according to source of funding and sector of performance (Business Enterprise, Higher Education, and Government), GDP, GDP Deflators, Purchasing Power Parities, Labour Force and Population.

Work is continuing on the preparation of a major consistent dataset on key macroeconomic variables, to cover all OECD countries from 1950 to the end of the 20th century. At present the data cover 23 countries to about 1995 but there remain many omissions. Data on countries which joined the OECD after 1990 (or left it) are not provided. The CEECs are not included because of data limitations. Sectoral breakdowns where provided are at the one-digit level (agriculture, mining, manufacturing, infrastructure, services, government). The consistency of the data is provided by 'snowballing'; that is, by talking the latest available data and retrospectively making earlier series compatible with the 'correct' recent results. All data are then cross-checked for internal consistency. It was hoped to have this as a major deliverable of the MACROTEC project, but time constraints have prevented its completion and updating.

Countries Included: Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Japan, Luxembourg, Netherlands, New Zealand, Norway, Portugal, Spain, Sweden, Switzerland, United Kingdom, United States.

Variables: GDP at market prices, GDP at PPP rates, GDP price deflator, Real GDP in 1990 prices, GDP per capita, Inflation rate, Gross Domestic Fixed Capital Formation, Investment in Producer Durables, Investment in Machinery and Equipment, Sectoral Fixed Capital Formation, Deflated Capital Formation by Sector, Population, Wage Bill, Output (Value-added) by Sector, Employment by Sector (incomplete), Unemployment (incomplete), Exports, Imports, Visible Trade Surplus, Current Account Surplus, Nominal Interest Rates, Real Interest rates, Consumers' Expenditure (Food, Clothing, Rents etc.,

Household, Medical, Transport, Education, Miscellaneous, Total), Government Final Consumption (Defence, Social Security, Education, Health, Total), US Patents, GERD, BERD, HERD, Civilian R&D.

**CEC Countries**

Countries Included: Albania, Bulgaria, Croatia, Czech Republic, Hungary, Poland, Romania, Slovakia, Slovenia, FYR Macedonia, Yugoslavia, Estonia, Latvia, Lithuania.

Specifically for Hungary, Havas (from Partner no. 6) has compiled macroeconomic series for 1991-2000, for income, prices, wealth, money and trade. Unfortunately, as reported below, there is a paucity of R&D or S&T statistics for Hungary.

For Poland, members of Partner no. 7 collected:

- Macroeconomic indicators (1994-2000): fiscal policy (public debt, budget deficit), monetary policy (inflation, exchange rates, interest rates) and growth policy (GDP, industrial production, trade, FDI, and aggregate demand); at the three-digit level, and also in aggregation according to Pavitt and Nevin taxonomies.

- Technology indicators (1994-2000): R&D activities (expenditures and employment) in research institutions, higher education and industrial enterprise sectors, as well as innovative activities in enterprise sector, technology balance of payments; mostly at the three-digit level, and also in aggregation according to Pavitt and Neven taxonomies. Calculations of the total factor productivity index for two-digit and three-digit industries.

- Labour market indicators: aggregate annual data on unemployment, employment, wages at the two-digit level for industry (based on firms' reports for the period 1994-2000); data on skills, education, occupations, wages, employment, unemployment obtained from the Polish Labour Force Survey on the population over the age of 15 years (55,000 in each quarterly sample) - May 1994 - November 2000.

Kutlaca (working with Radosevic under subcontract to Partner no. 1) produced revised data on selected macroeconomic and S&T indicators for the very difficult case of the Republic of Serbia and Montenegro (1987-91) and continuing into the FR of Yugoslavia (1992-2000), a country which had left the OECD at the beginning of the 1990s. An indicator of the difficulty of this country is given by the price deflator relative to the previous year (=100), which ran at 9026 in 1992 and $222*10^9$ in 1993. According to these major revisions of official data, GDP per capita in 1994 prices dropped from $2684

in 1988 to $1186 in 1995, with a slight rise to $1306 by 2000. GERD as a % of GDP however rose somewhat, from 1.06% in 1987 to 1.4% by 1999. The number of all researchers fell over that same period, but researchers in industry alone nearly doubled.

Kutlaca and Radosevic worked further on these and other data in Year 2 of the MACROTEC project, extending the work to other Central and East European (CEE) countries. Data on cost structures (wages and salaries, materials), investment and output were collected from national statistical yearbooks for eleven CEECs, but time series were found to be good enough only for 6 of these (Bulgaria, Czech Republic, Hungary, Slovakia, Romania and Poland). Macroeconomic data were pooled with these using data from EBRD. Missing observations were handled using LSDV (least-squares dummy variables) methods.

### 2.1.2 Industrial Data

**Collected by Madrid Group (partner no. 9)**

Countries Included: Spain, France, Italy and UK.

Time Period: 1981-1996

Variables Included: Unit cost of labour; Gross fixed capital formation; R&D (1987-1996); Labour productivity; Exports; Imports; Production; Employment and market share in two markets: Latin America and Western Europe; Patents granted in the US (1987-1995); Real effective exchange rate (1981-1996); Public funds devoted to support firm´s R&D (for Spain only 1991-94)

**Collected by Lyon Group (partner no. 2)**

Countries Included: France, Germany, Japan, Netherlands, Spain, UK, USA.

Time Period: 1975-1996

Variables Included: R&D Expenditures; Value-added

### 2.1.3 R&D data: CEECs (collected by partner no. 5)

Countries Included: Bulgaria, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Romania, Russian Federation, Slovak Republic, Slovenia.

Time Period: 1990-1997

Variables Included: GERD, BERD, GOVERD, HERD, GBAORD, Personnel

Work on the primary included countries (Bulgaria, Hungary, Poland) by the relevant partners in those countries has involved considerable data re-evaluation. In addition, the wage data collected by partner no. 5 for other purposes is a major input in relation to WP3 below.

## 2.2. Trends and causation in S&T

### 2.2.1 Cross-country studies

For reasons that in analytical terms will be spelled out in section III.4. below, our prescriptions for the interaction between economic growth and technological change turned out to be at odds with the prevalent 'monetarist' or 'supply-side economics' view underpinning contemporary EU macroeconomic policy. What we found as empirical support for our new view is that increases in output (e.g. real GDP) frequently precede increases in measured technology effort such as R&D expenditures or patenting, especially in the longer term. Some countries do provide empirical support for the traditional supply-led model of growth economics, that increases in technology lead to subsequent increases in output (GDP); but a larger number support the 'reverse causation' that output rises first, and some countries indeed show indications of both (suggesting a pattern of 'cumulative causation'). More specific country studies in the MACROTEC project, such as that for Poland in its transition decade of the 1990s, also find output precedes technology (see below).

**Table 2.** Relationships between Total R&D intensity and aggregate GDP

| GERD / GDPP | Obs. | GERD leads | | GDPP leads | | DGERD leads | | DGDPP leads | |
|---|---|---|---|---|---|---|---|---|---|
| Neths. | 26 | | | | | -0 | *** | | |
| Belgium | 18 | | | +2 | **** | -1 | * | | |
| France | 32 | +1 | **** | +2 | **** | | | -1 | *** |
| Germany | 31 | +2 | **** | | | -0 | * | | |
| Austria | 19 | | | +0 | **** | | | -2 | * |
| Switz. | 22 | +2 | **** | | | | | -0 | *** |
| Denmark | 24 | +2 | **** | | | -0 | * | | |
| Finland | 20 | | | +2 | **** | -0 | *** | | |
| Sweden | 16 | +1 | **** | | | +1 | *** | | |
| Norway | 22 | +2 | **** | | | | | | |
| Iceland | 18 | | | +2 | **** | -1 | * | | |
| Ireland | 21 | +1 | **** | | | | | +1 | *** |
| UK | 20 | -1 | * | -2 | ** | | | | |
| Spain | 28 | +1 | **** | | | +1 | *** | +2 | *** |
| Portugal | 13 | | | +0 | **** | | | +1 | * |
| Italy | 31 | +2 | **** | | | | | | |
| Greece | 11 | +2 | **** | +1 | **** | | | -2 | *** |

*Source: von Tunzelmann & Efendioglu, 2001: 65.*

Notes: Obs. = Maximum no. of observations

Numbers in lead/lag columns represent years of lead

Signs in front of these numbers indicate positive/negative correlation

Significance levels:

* = 20% level or better

** = 10% level or better

*** = 5% level or better

**** = 1% level or better

Table 2 uses simple lead-lag correlations to detect the pattern of relationships between total R&D intensity (GERD) and aggregate GDP measured in PPP units (GDPP), both in levels and in annual changes, for countries of western Europe from 1963 up to 1995 (with much missing data, which are allowed for by panel-data estimation). The column headed 'Obs.' shows the number of observations when the data are in levels. The next pair of columns show instances where GERD appears to lead GDP, as in the traditional supply-led model, and then where GDP appears to lead GERD, as in the demand-pull model. F-tests on the correlation coefficients show that all the included correlations are very strong (significant at 1% level or better) except for the UK, where the (negative) signs contradict specification of a presumed positive association. Leads of zero years, as here for Austria and Portugal, are observed from the curvature of the correlation coefficients relating to surrounding lags.[2] Most of the observed lags in either direction are of 2 years, and there are some cases of strong lags in both directions (France, Greece), indicating a cycle of about 6-8 years in the underlying data. There is a slight majority in favour of a supply-led mechanism when measuring R&D intensity and GDP in levels. However when measured in differences in the final pair of columns, most of the supply-led correlations (DGERD leads) are wrong-signed, as are a number of those for demand-led (DGDPP leads), though the latter are positive for the 'cohesion countries'. This could suggest 'long and variable' lags in this relationship that are not detected in annual changes.

Similar assessments are undertaken of other pairs of variables that relate technology change to economic expansion. For instance, a comparison of R&D intensity (GERD) with gross fixed capital formation as a percentage of GDP (GKFR) shows that these are inversely related over this period, with a downward trend in the rate of capital formation and an upward trend in R&D, so most of the correlations in levels are negative. To the extent that the one is 'crowding out' the other, there is roughly equal evidence for the rising GERD reducing physical investment as for the falling investment giving room to raise GERD. In terms of differences, however, a rise in investment more often leads to a rise in GERD with a lag of about 1 year, so undermining the case for any direct 'crowding out'.

Patents, often regarded as a measure of technological output as opposed to R&D as an input (cf. Griliches, 1990), can alternatively be taken as the measure of technology. A major advantage of patents series is data availability, so most of the series here for individual countries begin in 1950. The evidence of correlations in levels (where the data

[2] The lead-lag direction was taken to favour GDPP if the correlations of leads of 1 and 2 years were greater than those of lags of 1 and 2 years, and conversely for GERD.

for both patents and GDP have been standardised on a per capita basis) strongly favours a supply-push mechanism, contrary to the results for R&D and even more to those of Schmookler (at an industry level). The evidence in changes reverses this judgment, with a predominance of demand-pull correlations in the shorter term (changes in GDP per capita lead changes in patents).

Table 3 is the summary of a large number of more sophisticated regressions, based on a structural form of the ECM type (error-correction model). These ECM equations are estimated for each European country in each pair of variables. The number of variables included here is wider, incorporating gross investment in producer durables (GIPD) as a sub-category of gross fixed capital formation (GFKR), and business and higher education expenditures on R&D (BERD and HERD) as sub-categories of GERD. Before running the regressions, Dickey-Fuller and Augmented Dickey-Fuller tests were run, to substantiate that almost all of the included series were I(1) when measured in levels, or I(0) measured in differences. The ECM approach allows simultaneous assessment of short-run and long-run relationships: as observed in the previous table, it is quite possible to have a negative short-run relationship pattern coexisting with a positive long-run one, and conversely. Table 2 examines each estimated pair of variables as leaders (proceeding down the rows) and laggers (proceeding across the columns), giving the short-run relationship in the first row (SR) and the long-run one (LR) in the second row for each variable. Signs show whether there is a predominance of positive or negative correlations cross the countries, with ± indicating that the numbers of positives and negatives are roughly equal. The letters indicate what proportions of correlations are strong: high, medium or low (M/L = medium to low, etc.). Thus for the demand-pull relationship from GDP to GERD, we conclude that the correlations are medium-to-low in the short run and also in the long run, but the former are negative, contrary to specification (as observed in the simpler regressions of Table 2 above). In the next cells across we observe a balance of positive and negative impacts of GDP on BERD in the short run, i.e. more demand-pull in the short run than for GERD as a whole. This is of significance for the Barcelona target objectives, even though the strength of the demand-pull relationship to BERD is rather modest. Comparing the top-right cells with the bottom-left cells, there is some indication, again rather modest, of stronger demand-pull than supply-push mechanisms insofar as they can be established from these data. Thus investment (GFKR and GIPD) has a positive medium-level long-run impact on patenting (PATM) but the reverse link is negative.

**Table 3.** Summary of ECM results from the key variables: signs and significance

| From: | To: | GDP | GFKR | GIPD | GERD | BERD | HERD | PATM |
|---|---|---|---|---|---|---|---|---|
| GDP | SR | | + H | + H | - M/L | ± M/L | - M/L | + L |
| | LR | | - H | - M/H | + M/L | + M/L | + M | + H |
| GFKR | SR | + H | | | ± L/M | ± L | - M/L | + L |
| | LR | - M | | | - L/M | - M/L | - M | + M |
| GIPD | SR | + H | | | ± L | ± L/M | - M | + L |
| | LR | - M/L | | | ± M/L | ± M/L | - M/L | + M |
| GERD | SR | - M/L | ± L/M | ± L/M | | | | |
| | LR | + L/M | - L | - L/M | | | | |
| BERD | SR | ± M/L | ± L/M | ± M/L | | | | |
| | LR | + M/L | - L/M | ± M/L | | | | |
| HERD | SR | - M/L | - M/L | - M | | | | |
| | LR | + M | - M/L | - M/L | | | | |
| PATM | SR | + L | + L | + L | | | | |
| | LR | + M | - M | - M | | | | |

*Source: von Tunzelmann & Efendioglu, 2001: 76.*

Variables: GDP = Gross Domestic Product at factor cost

GFKR = Gross Fixed Capital Formation as a % of GDP

GIPD = Gross Investment in Producer Durables as a % of GDP

GERD = Gross Expenditure on R&D as a % of GDP

BERD = Business Expenditure on R&D as a % of GDP

HERD = Higher Education Expenditure on R&D as a % of GDP

PATM = US Patents granted per Million of population.

Note: H = high proportions of significant correlations; M = medium; L = low; and so on.

+ = mainly positive correlations; - = mainly negative correlations (cases where there were roughly equal numbers are shown as ±).

SR = short run; LR = long run.

These and other results from country studies lead us to conclude that the traditional supply-push approaches to the link between R&D and output growth should be at least complemented by demand-pull reverse links, which if anything may be somewhat stronger.

The studies by Efendioglu working with von Tunzelmann (from Partner no. 1) lead to the following main conclusions:

1) Cost-based supply factors like prices, wages and interest rates appear to have a rather limited impact on growth and capital formation. This contrasts with, for instance, the position taken in the EU's Green Paper on Innovation in 1995, which considered only the cost side of macroeconomic impacts. We have found some cases of apparent influence, but they need to be considered in a broader interactive context than is usually studied in economic research.

2) Part of that broader context is the need to embrace both the demand side and the supply side. Overall, the demand side appears to provide a more consistent guide to explaining technological performance than does the supply side, though evidently both are involved.

In terms of such cross-country studies, a paper by Le Bas (from Partner no. 2) examines two types of relationship from the macro level to R&D at the micro level. The two pathways considered are the macro effect via the multiplier and the effect of demand variations via effects on liquidity. The relationship is investigated at the sectoral level for 7 countries, using an error correction model (ECM) in slightly different format from the papers by von Tunzelmann & Efendioglu. Current findings are: i) there is a strong short-term effect of demand variations on business R&D expenditures in the short run, though more at the level of manufacturing as a whole than at the level of individual sectors; ii) the long-run effect is quite weak; iii) the short-run effects are weaker in the first period considered (1976/86) than in the second one (1987/96); iv) the R&D-intensive industries have higher elasticities of response; v) there are some country effects.

A paper by Knell (from Partner no. 5) uses Kaldor's specification of the Verdoorn relationship to estimate 'increasing returns' in both western and eastern European countries in the 1990s, based on recently published data. The estimates show, among other things, the percentage response of labour productivity growth to a unit increase in output growth. By this measure of 'increasing returns', led from the demand side rather than the usual supply side, there was a rise of about 0.66% in labour productivity in

western Europe and from 0.70% to 0.85% in eastern Europe from a 1% rise in output. The specification of these equations is however controversial in the literature (e.g. Rowthorn, 1975), and Knell is pursuing his findings further.

### 2.2.2. Transition and short-term effects on S&T

A more specific study of Poland has been conducted by Kubielas, assisted by Brzozowski and Niedbalska (Partner no. 7). In the context of the MACROTEC project, they consider two blocks, macroeconomic performance and the RTD system, each with two interfaces: supply (costs/prices) and demand (GDP, gross capital formation, exports etc.) for macroeconomics; input (R&D, RSEs, FDI etc.) and output (TFP, new products, patents, technological balance of payments - TBP) for RTD. Of the various possible interlinkages they consider five, namely macroeconomic supply/demand on RTD input/output, plus RTD input on RTD output. From this are adduced a set of indicators which we have used communally in MACROTEC. The main theoretical models utilised are the Dixit/Pindyck/Brzozowski for effects of macro supply and Kaldor/Verdoorn/Schmookler for effects of macro demand (the latter were surveyed in WP1). Estimation was based on panel data for 22 two-digit manufacturing industries for 1994/9. Inflation was found to be non-linearly related to innovation (TFP), as predicted by the Brzozowski model. Increasing exchange rate variability lowered innovation, while increasing the restrictiveness of fiscal policy raised it. Results for new product innovation were more mixed. So far as RTD input (BERD) was concerned, tight fiscal policy appeared to have the opposite effect, of lowering it, possibly through restricting upstream expenditure. High levels of inflation discouraged inflows of FDI, but FDI was insensitive to exchange rate variability. Turning to macroeconomic demand as opposed to supply, there was a strong Kaldorian effect on TFP, with restrictive demand management lowering it, though there was little observable impact on new product innovation. Finally, for the link between RTD inputs and outputs, BERD and FDI had a positive impact but the skill ratio a puzzling negative one. BERD, and exports more generally, appear to depend on prior imports to grow.

In an invited address at the Madrid meeting, Andrzej Jasinski (University of Warsaw) examined the relationship between macroeconomic fluctuations and the 'innovation scene' in Poland, 1990/99. The model was based on the Triple Helix, of interactions between government, science and industry, with special reference to units for technology-transfer infrastructure ('uttis'). Principal components analysis was used to synthesise four main indicators of innovation performance. This was shown to follow the same pattern over time as GDP growth, but with a lag of one year (recently two years), thus indicating a demand-driven pattern for innovation derived from GDP growth.

Jasinski then turned to the evolution of S&T policy, and showed that it too lagged behind the macro-economy. The policy was excessively variable and still to oriented to science rather than technology transfer from domestic R&D sources. Restrictive macro policies at the beginning and end of the 1990s curtailed innovativeness, though the government was not solely to blame. The author concluded with policy recommendations, summarised in 'five Cs': policy should be coordinated, correlated (science with technology), comprehensive, compatible (S&T with macroeconomics), and coherent (with the EU).

A paper by Chobanova (from Partner no. 8) assesses the new market-based environment for S&T in Bulgaria. She points out that the previous command economy relied mainly on supply-push, although there was a rather artificial demand-pull coming from the external market formed by other members of the CMEA (mainly for some high-tech products from Bulgaria). The loss of this since 1990 has not been replaced by any significant demand-pull from western or other foreign markets, so the S&T system has fragmented as between supply and demand. Internal demand-pull is almost all that is left on the demand side, but this is hampered by restrictive macroeconomic policies. Domestic investment has declined in this macroeconomic environment, while FDI remains much smaller than hoped for. On the supply side of innovation, the direct state contribution to R&D has fallen to just 0.18% of GDP, there is no clear government policy, and promising new fields such as IT are being neglected. Private R&D is not large enough to bring the overall intensity up to as much as just 0.5% of GDP. Numbers of R&D personnel in both research institutes and private enterprise have been dropping. However patenting has continued at reasonable levels in high-tech areas. Chobanova's study then draws on two surveys of the Bulgarian innovation system, the first in 1997 following Oslo Manual prescriptions and looking mainly at sources of and obstacles to innovation, the second in late 1999 looking specifically at IT in 42 firms. The former showed that export-oriented firms are much stronger innovators, marketing activities are not seen as important drivers of innovation, firms do not regard research institutes as important sources of innovation though the latter reverse this view, and the worsened financial environment following transition hampered innovation. The later survey showed that SMEs dominated as both suppliers and users of IT, but suppliers have not yet won external markets (these data are particularly valuable for the breakdown of software activities they provide). The implication for state policy is the need to boost demand by restructuring the national innovation system. Three areas of state actions are called for: i) improving general conditions (better legal framework, fiscal environment, trade policies, basic education, infrastructure, etc.); ii) renovating the S&T base (strategic R&D, social R&D, basic research, technical education, etc.); and especially iii) transfer factors (inter-firm

networking and regulation, spin-offs providing experts, IPRs, international relations, etc.). Dynamic factors linked to absorptive and generative abilities of firms could be especially productive.

For the case of Hungary, a report by Havas (from Partner no. 6) surveys the work of his group. This begins by pointing out that in the 1990s macroeconomic policies had to be 'softened' below what was ideally required for major change because of the need to make the transition process acceptable to the country's citizens. From 1990 until 1997 these seemed to be a trade-off between macroeconomic equilibrium and growth, with tight policies dominating in most years. Tight policies have severely reduced the government's capacity to fund R&D. The substantial role of FDI implies a lower impact of domestic macro policies (FDI is much directed towards exports to EU countries, so demand factors are also externalised). Despite many draft policy documents, there was no R&D or S&T policy in Hungary until 2000, and few statistics. Implicit R&D policies have concentrated recently on promoting networks, especially university-industry links. The Szechenyi plan now operating raised R&D funding in 2001 and intends to continue this increase. With the absence of any explicit S&T policy there has been no obvious path for integrating them with macroeconomic policies.

Another paper by Knell (from Partner no. 5), presented at the Athens meeting, poses a different variant of this sort of question. Knell investigates why it was that, in the CEEC transition countries of the early 1990s, R&D fell much faster than GDP, i.e. faster than its most obvious demand-side determinant; he explains this as being mainly because the countries were well 'above the line' pertinent to their respective income levels pre-transition. The research involves some elaboration by the author of official statistics on productivity growth and indexes for technology growth (R&D expenditures and personnel, and patenting). Knell includes his own calculations of the sectoral distribution of R&D for a number of CEECs, and incorporates the results of some recent innovation surveys (Poland, Slovenia and Hungary). He also develops further an IMF index for the 'technology balance of payments'. He concludes from both the innovation surveys and the latter that FDI may not be a particularly adequate measure of technology transfer to the CEECs, a point we take up further in WP5 below.

### 2.3. Foreign inputs and domestic technology

The above studies focus mainly, though not exclusively, on the impact of domestic economic growth (and decline) on technology. For many of the countries joining the EU over recent years the impact of accession has been, or is anticipated to be, a rising importance of external growth. Questions of trade policy etc. are taken up more extensively in section III.4. below, but here we can note some ways in which enlarged external resources boosted domestic technological facilities – or proved disappointing.

#### 2.3.1. FDI and national systems

Jose Molero (Complutense University, Madrid) presented the invited introductory address for the conference in Madrid, at the institute with which he had long been connected. His paper examined the relationship between industrialisation and internationalisation of the Spanish economy since the 1950s, highlighting three themes: sectoral change and the integration into a new international division of labour; innovation and the incomplete catching-up of the Spanish economy; and a shift in FDI from targeting the domestic market and low wages to more open strategies including capital exports. The key factor inducing (partial) shift in these factors was Spain's entry into the European Community in 1986. These specified elements were interlinked, because a strong performance in international competitiveness of the economy arose despite a weak performance in high-tech activities, mainly because of a lack of MNC involvement in such fields. Technological advance has remained dependent on foreign sources; it is specialised even now in intermediate rather than high technology, and shows a lack of coordination between public and private sectors (though higher educational levels have improved domestic absorption of imported technology). MNCs contributed over 50% of BERD in the early 1990s and a high proportion of innovative activities according to CIS, though the latter can be accounted for by differences in size and sector from average domestic firms. Studies of the Spanish subsidiaries show a declining association with internal economic forces and a growing one within their wider multinational operations. Molero's paper evoked many similarities we have been observing in other countries, especially in Central and Eastern Europe.

In her invited paper at Madrid, 'Growth, innovation and specialization patterns – history and institutions in intermediate countries', Isabel Salavisa (Dinamia, ISCTE, Portugal) compared the four 'cohesion countries' of Ireland, Spain, Portugal and Greece. From similar starting points in terms of GDP per capita around 1980, the four countries then followed diverging paths. Ireland by 1997 had actually surpassed average EU levels and, alone of these four countries, could be said to have successfully caught up. These

differences are argued as being related to their different specialization patterns and to their uneven capabilities of attracting FDI and adopting (and adapting) innovation. The author divides approaches to catch-up and the role of technology into 'accumulationist' (including new growth theory) and 'assimilationist' (e.g. evolutionary). The latter require a much more active entrepreneurial response in the country receiving FDI and inflows of technology, and hence stress differing national responses. Ireland was able to push labour productivity even faster than wage increases because of its specific social agreements, whereas the other three countries failed on one or other score. Ireland was also quite distinctive for its shift of production and exports towards high and medium-high tech industries. To what degree foreign high-tech implants have taken deeper root in Ireland remains an open question, though the country scores very highly in terms of innovation-based growth. Historical elements and even chance contributed to Irish success. However it may be reasonable to conclude that, compared with say Portugal, Ireland has gone farthest in terms of post-Fordist growth patterns.

### 2.3.2. Cumulative causation vs. technology gaps

Fulvio Castellacci (TIK, Oslo) presented an invited paper at the Madrid conference written jointly with Isabel Alvarez, appraising Spanish growth from 1960 to 1997 in the light of two theoretical perspectives. One view is the Regulationist-Kaldorian one, taking up the notion of cumulative causation, but reinterpreted from a Regulation School perspective (see the background paper for WP1 on these approaches). A possible alternative is the technology gap approach, according to which international trade patterns are driven by cross-country gaps in technology and efforts to overcome them. Building partly on previous theoretical discussion, the authors interrelate these two kinds of approach and develop them in an 8-equation model. Properties of the model are developed at a theoretical level before proceeding to a historical consideration of the experience of Spain. Two main time periods are examined: the first going from 1960 to 1975, the second from 1982 to 1997 (the intervening transition years are not treated). After estimating the model by two-stage least squares, the authors argue that the first period is dominated by internal changes within Spain, despite the decline of autarky as the period progressed. The main determinants of productivity growth were probably dynamic economies of scale and growing size of the internal market, in Kaldor-Verdoorn fashion. For the later period the econometric results are less clear-cut, and the Kaldor-Verdoorn effect disappears. In this period of much greater openness of the economy, the technology gap effect becomes the dominant explanatory factor. This was linked to a distributional shift from a primary impact of growth on real wages in the first period to a primary one on firms' profits in the second. The authors conclude that, for the case of Spain at least, the cumulative causation and the technology gap views are alternatives

rather than being complementary, and relate naturally to differences in the country's economic context.

### 2.4. Meso and micro level impacts: 'transmission mechanisms'

The ways in which the impacts of aggregate demand (from output growth to technology growth) as well as aggregate supply mechanisms (from technology growth to output growth) are propagated through economies depend on linking structures at the meso level (sectoral) and micro level (firms etc.). By analogy with monetarist models of the alleged impact of inflation on growth, we shall term these 'transmission mechanisms'. Although we did not make a complete study of these, in view of the mainly macro focus of the MACROTEC project, some significant findings were made.

Here we will consider some of these mechanisms operating at the micro level of firms or meso level of industries (later we will take on some more macro-level mechanisms). In terms of such micro/meso 'transmission mechanisms', from a Schumpeterian perspective we can distinguish 'Schumpeter Mark I' firms and industries (typically SMEs swarming into new niches) from 'Schumpeter Mark II' firms and industries (typically large firms in established activities). We can leave aside academic concerns about whether these adequately describe Schumpeter's own conceptions, and accept that empirically they fare well for separating European industries into two main groups, according to the studies of Malerba and colleagues (e.g. Malerba & Orsenigo, 1996). Our studies from various partners and countries find that both groups are important for sectoral levels of innovation, though comparative advantages of countries are mainly determined by their structure of large firms and associated industries (Mark II). Preliminary research also suggests aggregate demand factors may have an important 'pull' effect, especially on the setting up of SMEs in technologically advancing areas (Mark I) (see the work by Le Bas on France and across countries). In more detailed data for the Netherlands, it appears that upgrading of skills occurs mostly through new entrant firms (see the work by the MERIT group, Partner no. 3). Another study for that country suggests that its large firms are more affected by (labour) cost factors and also international forces, whereas medium and smaller firms respond more to domestic fluctuations in policy (see the work by Dunnewijk). Generally, we would therefore conclude that micro-level activities are driven by specific conjunctures of supply and demand factors, among which need to be included aggregate supply (cost) and aggregate demand factors, i.e. the macro-level determinants. These micro-level activities embody technological accumulation, i.e. the R&D performances.

An equally popular way of envisaging key choices in Schumpeter's framework lies in his own emphasis on 'creative destruction' versus the alternative view of 'creative accumulation'. Schumpeter indeed envisaged the swarming of Mark I firms as the outcome of a creative destruction process. Monetarist-inclined governments such as that of Mrs Thatcher in 1980s Britain have interpreted this as a call to sacrifice 'sunset industries', and the question of whether or not to prop these up remains a problematic issue for national and indeed EU administrations to the present day (the Common Agricultural Policy can be seen in this light). A contrary view is however that technological processes, especially, are cumulative rather than destructive. Science and technology are both 'path-dependent'; adapting Newton's words they build on the shoulders of giants, because of the idiosyncratic and often tacit nature of knowledge acquisition. One way of resolving this tension is to conceive of 'creative destruction' occurring principally in product markets and 'creative accumulation' mainly in technology inputs (other inputs such as skills show both patterns).

### 2.4.1. Technological natality

In pursuing the nature of creative destruction and creative accumulation, the paper presented by Christian Le Bas and Syoum Négassi (LASI, Université Paris1) assessed the impacts of 'technological natality' (the birth of 'new firms') and firm innovative persistence (the role of existing large firms), through a study of their patenting. These two variables are seen as representing the two main processes of innovation dynamics in the Schumpeterian perspective, and their impacts fall on two characteristics of technological performance: sectoral innovative intensity and international technological specialisation. Using patents data for 1996-98 in 3 countries (France, Germany and the UK), they estimated models for sectoral innovative intensity measured by the average number of patents per firm and the revealed technological advantage, an indicator of international technological specialisation. For sectoral innovative intensity it was found (after controlling for technological characteristics) that the size of the sector is a significant explanatory variable, the influence of demand conditions is weaker, industrial concentration has a limited impact, and both technological natality and firm innovative persistence have significant and positive impacts. These results confirm the two basic Schumpeterian models of innovation (creative accumulation and creative destruction). For revealed technological advantage our results show that industrial concentration and firm innovative persistence are the main determinant factors, and that demand conditions, size of the sector, technological concentration and technological natality have no significant impacts. These results indicate that for revealed technological advantage the Schumpeterian model of creative accumulation (the Mark 2 model) is the only significant process.

### 2.4.2. Firm-size effects

At the transmission level of individual firms, Theo Dunnewijk has developed new econometric results relating to the impact of macroeconomic fluctuations on different types of R&D performers in the Netherlands. The structure of R&D is disaggregated into four types of actors: large corporations, smaller firms, institutions and universities; but the amounts each funds and the amount they actually carry out themselves differ. Dunnewijk shows a declining share of the top 5 enterprises in Dutch R&D while the other actors are roughly stationary from the early 1960s until 1998. He then develops a list of macro-economic explanatory variables and proceeds with Granger tests of causality, using various lags of the explanatory variables. Among the list of financial and cost variables, only the wage rate appears to have causal effects in Granger's sense, principally on domestic companies. The interrelationships with gross capital formation are however many and complex. Macroeconomic fluctuations appear to have less impact on the large corporations than others – international conditions like the exchange rate have a more pronounced effect on the former. The findings show the importance of interrelating the macro variables with the meso level of actors in the economic system for understanding macro-level impacts.

## 3. Technology, employment, skills and macroeconomic performance: WP 3

A more extended analysis of these meso and micro level factors within the MACROTEC project came in WP3, where the objective was to look in greater detail at employment issues, focusing on the much studied areas of technology and skills. A full survey of work in this area would take us too far afield, but we can concentrate upon the relationship to macroeconomic performance with a view to looking later at the implications for macroeconomic policy.

### 3.1. Employment, productivity and growth

The wider literature, to which our members have made some contributions, takes the rising inequality between skilled and unskilled (or nonmanual and manual) workers, particularly between the 1970s and the (early?) 1990s as its key feature to be accounted for.

a) The most popular explanation, especially in the USA, to explain the rising skill premium has been radical technological change, in particular the advent of the ICT 'revolution', which privileged computer literacy skills. This has however encountered several challenges. One is the 'Solow paradox', claiming that technological change was not very rapid in this era, because productivity growth

slowed down. Another is the difficulty of reconciling this view with the acceleration of ICT diffusion in the 1990s coexisting with an ending of the trend to greater inequality (possibly labour supply by then had risen to meet the new demands, but why?). A third problem is the recent stress on 'skill-biased organizational change': that technological change had little impact without reorganization (Bresnahan et al., 2002).

b) A second possible explanation comes through international trade factors, especially the view of Wood (1994) that rising industrialization in East Asia and other Third-World countries led to undercutting of unskilled wages in the advanced industrial countries.

c) A third view is that changes in 'governance', especially the rise of monetarist-inspired governments with an agenda for cost-cutting and a willingness to tolerate high unemployment, could explain the adverse shifts, especially during the 1980s. However it is not clear how much impact such government policies had over and above the other factors mentioned. An alternative or supplementary view is that governance changes at the level of corporate organization fostered 'downsizing' and higher unemployment.

d) A compromise view is that, while the debate has been all about which of the competing explanations is most important, perhaps all are interlinked in the longer term.

Some of the most significant issues raised in the literature that bring in questions of employment impacts in regard to our central subject of study are thus: i) the existence of increasing or decreasing returns; ii) the 'Solow paradox' of the coexistence of radical technological change and a productivity 'slowdown'; and iii) the roles of labour demand and labour supply. These issues turn out to be interconnected, and all are highly relevant to our main topic.

Michael Landesmann and Robert Stehrer (from Partner no. 5) conducted a formal analysis, using a classical model to develop the wage/profit and consumption-investment/growth tradeoffs. The main difference from orthodox models was the stress on out-of-equilibrium and between-equilibria (transition) dynamics, though introducing some Keynesian and Schumpeterian features. The key to the results as applicable to WP3 was the role of the real wage in permitting full employment in the face of exogenous productivity and labour shocks. Rents emerge in a Schumpeterian manner, as in some of the literature on wage-employment inequality, and the subsequent spending of those rents may prove crucial (e.g. financial 'leakages'). Endogenous growth of a Kaldor-

Verdoorn kind (productivity growth is a function of output growth) is then admitted into the model through simulations. With leakages, technology shocks may have a detrimental effect on productivity growth, as in the US of the 1990s; with improved financial mechanisms (e.g. venture capital in the 1990s) those leakages may be plugged and the productivity performance improved. Hence the model is able to simulate the Solow paradox.

Findings from the macroeconomic end in terms of our cross-country studies as considered in WP2 above seemed to lead to the following conclusions:

1) Technology appears to have had, on balance, rather beneficial effects on employment, in contradiction to the often-expressed views about technological unemployment. The result needs however to be interpreted in a broad, interactive context.

2) Nevertheless technological change, and especially the rise of ICTs in modern times, has had adverse distributional effects in the medium term. Skilled earnings for creating and using new technologies have widened differentials over the unskilled. This may reverse in the longer term, as the benefits of wider and cheaper access to these new technologies spread.

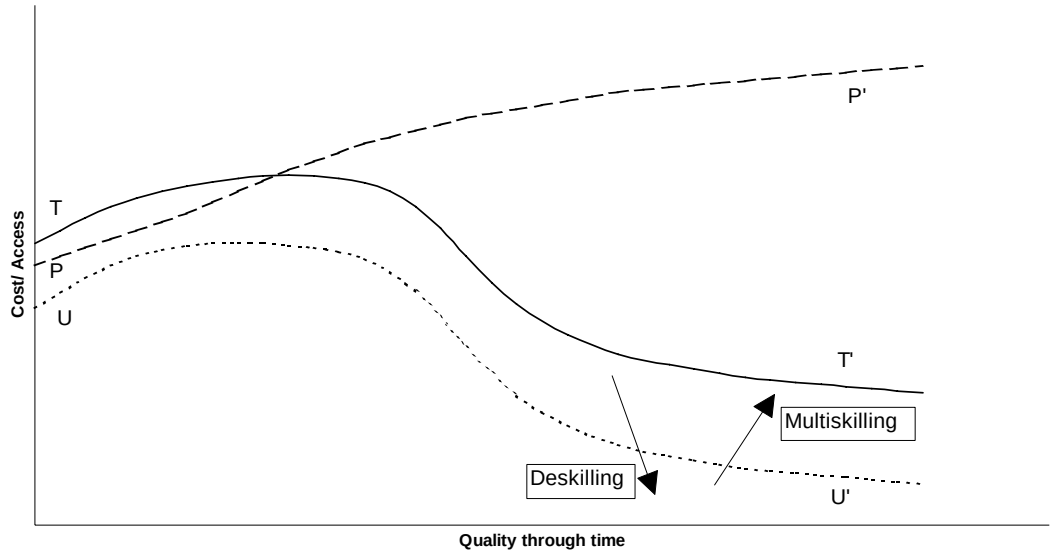
3) For similar reasons, rising R&D since the early 1970s has been associated with somewhat slower growth of national economies over that period. This suggests a pattern of 'diminishing returns' to R&D increases, contrary to the increasing returns posited by 'new growth' theory. Although this may well be the case, we consider that this is a necessary price to pay for launching new technological paradigms, and that 'increasing returns' may still eventuate in the fullness of time. The consideration of skills in WP3 provides an important clue as to why such diminishing returns should have prevailed in an era of radical technological change.

### 3.2. Skills and technology

The rise of ICTs and other radically new technologies is claimed to have put pressure on supplies of skilled as opposed to unskilled labour. The studies of Howell and Wolff (1992) and Wolff (1996) clarify this by emphasising that the demand was for different kinds of skills – traditional skills (those requiring manual dexterity) were no more in demand than the unskilled, whereas cognitive skills (those requiring mental dexterity) and interactive skills (those requiring managerial or other socially interactive abilities) were much needed.

This can be captured in a simple formulation of skills trajectories resulting from radical technological change, as in Figure 1. On the one side we suggest there were changing patterns of skill requirements associated with new technologies, though somewhat more complex than a simple 'skill bias'. In the schema set out in Figure 1, the conception and generation of new technologies – research skills – rises as the technologies evolve and perhaps never really subsides, so such skills continue to be in high demand for developing these new technologies (curve GG'). The skills associated with producing the new technologies, or the products in which they are embedded, also rise initially but after a time probably start to decline, as learning mechanisms (learning by doing) give rise to improvements in and streamlining of production processes (curve PP'). The skills associated with using the products of the new technologies also are high and perhaps increasing to begin with – think of an early computer or predecessors of the internet – but after some point these skills start to decline rapidly (curve UU'). This is not just because of 'learning by using' among users but also because the product becomes more and more accessible to them (laptop computers with friendly interfaces, Internet access via CD-ROM plug-in, etc.). This is the stage where major productivity gains accrue. Until then, the rise of new technologies is likely to meet rising costs (diminishing returns), as the problems of generating and producing them step up and access is limited. If there are to be increasing returns, they come considerably later, when access is not just straightforward for users by the technologies become embedded in a wide range of products ('general purpose'). This suggests one explanation for the 'Solow paradox', and an important reason why productivity trends differ over time from technology trends.

**Figure 1.** Labour Costs of Producing and Using Technology through Time



We shall review our conclusions in sub-section III. 3.3 below, but first we shall first survey some of the more direct contributions made in the MACROTEC project.

### 3.2.1. Analytical approaches

Central to our theoretical approaches to the issue of skills is a sequence of papers by van Zon and colleagues (from Partner no. 3). The authors make use of an endogenous growth model in which technological change is the outcome of purposive R&D investment by firms, emanating partly from strategic behaviour on their part (so new technological opportunities are assumed to exist). The empirical background is one in which unemployment is much higher among the low-skilled than the high-skilled. A second key theoretical element in the paper (which has gone through several versions in the course of the MACROTEC project) is the product lifecycle model, in which skills may be in especially high demand at early stages of introducing a new product, though over time new production processes are developed which create a greater proportion of low-skilled jobs. This has strong resemblance to the empirical findings of von Tunzelmann and colleagues, as just mentioned: the main difference from the latter approach is that high-skilled labour is assumed to be substitutable between product R&D, process R&D and final good production by van Zon, whereas von Tunzelmann takes them (as in Figure 2) to follow three different and non-substitutable trajectories. The van Zon model allows the consideration of many types of macroeconomic policy impact, via both the demand side (e.g. demand for products, especially new products) and the supply side (e.g. costs of capital and R&D), although the demand for technologies is not explicitly considered. Some scenarios are developed using simulation experiments based on artificial data. Typical experiments so far conducted include: i) increasing the supply of high-skilled labour (this lowers the wage premium of the high-skilled in the short run but raises demand for new products and also for the skilled labour to create and produce them, so can actually raise the premium in the long run); ii) increasing the supply of low-skilled labour (this does lead to a permanent fall in low-skilled wages); iii) increasing the rate of discount (this makes R&D less profitable); iv) increasing the productivity of R&D workers on both products and processes. The simulations appear to be compatible with the stylised facts observed in empirical research, and can be extended to incorporating 'real' data; they also provide a way of finally integrating these much more analytically developed studies with the schema of Figure 1.

Van Zon subsequently developed the model of skill interactions that he had first outlined at the Vienna meeting, in 'A note on growth frontiers and labour market policies'. By adding an input-output framework to the earlier model, and developing the analysis through a linear-programming perspective, he is able to set out a 'growth possibility

frontier'. Through this he can explore the indirect as well as direct bottlenecks in skill supply from given changes in demand. The model is being filled out on the basis of empirical data. The impact of policy-making will also be further developed.

An initial paper by Sanders (also from Partner no. 3, and one of van Zon's principal collaborators) aimed at putting empirical flesh on these analytical bones. In particular, his work outlines a procedure for investigating the apparent paradox that the premium on skilled labour has been rising for around two decades despite a rising relative supply of skilled labour. The van Zon approach above has shown how this could be attributed to the existence of different types of technical change. A survey by Sanders and Ter Weel has appraised over 70 empirical studies of skill-biased technical change. They observe strong heterogeneity among firms – most skill upgrading in practice seems to come from the growth of skill-intensive firms and the demise of unskilled-intensive firms, which limits the amount of 'substitutability' (this point may also be linked to the work of Le Bas on new firm formation for WP2). More recent work by Sanders, still under development, outlines his intentions to implement the van Zon approach of crucially distinguishing product R&D from process R&D using data for the Dutch economy, based on firm-level surveys for 1995/9. Firm-level data will allow detection of the heterogeneity bias. The outcomes are expected to cast light on European policies for labour markets and technology, in particular the tendency to treat R&D as homogeneous when in actuality it is not.

In later updating his work based on the Van Zon model, Sanders found that data availability (in applying the model to the Netherlands) turned out to be a problem for long time series and thus assessing full dynamic efficiency, though the work on short time series and quasi-dynamic efficiency has proceeded, using extensive firm-level data. The above reformulation using input-output is made use of. Growth of final output can be limited not only by static inefficiency but also by quasi-dynamic inefficiency, i.e. skilled labour shortages in relevant R&D. Findings to date include that skill varies a lot across sectors, and skill-intensive sectors have a higher probability of innovating their output. There is a weak positive link between increasing skill intensity and innovation output (this offsets the surprising negative finding by Le Bas noted for WP2). There is however a weak negative link between increasing skill intensity and process innovations.

### 3.2.2. Findings for the transition countries

Empirical work on Central and East European countries has been conducted at WIIW (Partner no. 5). A paper by Peter Egger and Robert Stehrer examined international fragmentation through outsourcing in respect of trade in intermediate goods for 3 CEECs (Czech Republic, Hungary and Poland). They find a marked impact of both exports (especially) and imports of intermediate goods on the wages of unskilled workers. In Hungarian manufacturing, the intermediate goods trade with the EU alone has led to a fall of 58% in the predicted skilled/unskilled wage bill ratio since 1993 (31% in the Czech Republic and 30% in Poland).

A paper by Landesmann and Stehrer made available at the Brussels wrap-up meeting discusses the evolution of competitiveness, industrial and trade specialisation of the countries of Central and Eastern Europe (CEECs). It is shown that the paths taken by the different CEECs have been quite diverse, and the paper attempts to show that a combination of a catching-up plus a trade specialisation model is required to understand the patterns of specialisation emerging there. The paper starts with a description of the main features of macro-structural change and moves on to discuss patterns of productivity and wage catching-up across industries, which give rise to interesting movements in comparative cost dynamics. This is complemented by an analysis of patterns of trade specialisation, including measures of product quality upgrading. Information is added about the industrial allocation of FDI and comparative educational attainment as well as the evolution of labour demand by skill groups. All the above yields an interesting (and at times unexpected) picture of the evolving division of labour in an Enlarged Europe.

A report from Havas (from Partner no 6) reports on progress towards modelling the Hungarian labour market, using concepts drawn from human capital theory though not the theory itself. Skills are regarded as a latent variable of seniority, education and occupation, and the time pattern of rents from skills indicate the balance of demand and supply for skills. Observations are based on data from over 100,000 employees per year, and there are intentions of drawing comparisons with other countries. The results will be linked to the macroeconomic data for Hungary which Havas has produced, as described earlier in WP2.

Gabor Kezdi (University of Michigan and Institute of Economics, Hungarian Academy of Sciences, subcontracting to Partner no. 6) supplied a paper on labour market transition in Hungary, 1986-1999, which took the rising skill premium as its main theme. The fall of the socialist system was associated with first a period of major job destruction and

intersectoral labour reallocation (1987-95), then second one of rebounding employment and more equal skill upgrading. Through a valuable collection of data from reconciling multiple sources, the paper establishes the primary role of labour demand in influencing skill premia, though a feedback effect through enrolment on labour supply can also be observed. The paper supports the 'skill-biased technological change' view, in seeing new technology and new capital (proxied by foreign ownership) as the main source of changing labour demand, but admits that direct evidence is hard to find. It is not clear how well this argument can explain the different patterns after 1995 (in advanced as well as transition countries), nor allow for the recent shift of theoretical emphasis to 'skill-biased organizational change' noted above (which may also be linked to foreign ownership).

Research by Socha (from Partner no. 7) in conjunction with Andrew Newell of the University of Sussex, UK (whose involvement comes from an overlap with another Fifth Framework project), showed a shift into services and thus into non-manual occupations in the 1990s in Poland, though the latter was not of great magnitude, nor (at that time) was the increased wage premium for non-manuals. Much more dramatic was the increased premium within manufacturing, which their paper set out to examine. Comparison across industries suggested that Polish net exports were concentrated in industries such as office machinery with low non-manual premia in the early 1990s, though there was a shift to net exports from industries with low manual wages and less rapidly rising premia during the 1990s. The authors explained the differential rises in premia across industries by two factors, differences in productivity growth (technological change) and shifts of domestic demand towards high-growth goods. The latter may have been accelerated by macroeconomic boom.

This work was updated in the paper presented by Newell and Socha at the Madrid meeting, on the rising nonmanual wage premium in Poland. In that country the gap between nonmanual and manual wages rose about 20% between 1994 and 1999. This is examined in the light of the conventional debate between technology and trade determinants, about which the authors are however critical of earlier studies. Like the Egger-Stehrer paper they use 2-digit manufacturing data. They find the growth in the skill premium is much faster during the late 90s in industries that are already largely privatised before 1994, and also in industries with a higher initial level of R&D spending. There is some effect also, though weaker, of initial trade orientation, partly because net exports are shifting their composition away from previously export-oriented sectors. Overall the authors are critical of the labour demand approach to the premium because of very different increases in different industries. They find more in common with the

recent trade approaches such as Feenstra & Hanson (2001). The reconciliation of these findings with those from WIIW remains an open question.

### 3.3. Constraints on R&D impacts

In sections III. 1 and III. 2. above we have suggested on both theoretical and empirical grounds that supply-push attempts to increase R&D in a context of rigid demand constraints will make little headway, a point we will elaborate into a full-scale presentation in section III. 4. below. In this sub-section, we indicate why issues of labour demand and supply, especially in relation to skills, constrain any attempt to expand R&D from having equiproportionate impact on the growth of national output. This perspective appears compatible with a 'new growth' approach and its emphasis on constant returns only to 'broad capital', but we shall put the argument somewhat differently. Another constraint on expanding R&D, the role of institutions, is developed further in section III. 4.4. below.

The 'régulation' approach to political economy is built primarily from considerations of the labour market and its relationships with aggregate demand. Two key aspects of European labour markets since the ending of the postwar 'golden era' around the early 1970s have been the persistence of high unemployment, and rising levels of inequality between various classes of employed workers. The former was dismissed by monetarist writers as being the consequence of changes in the 'natural rate of unemployment', but as attempts to explain the latter by monetarist arguments largely failed, this did not really amount to an explanation at all. An implication of the supply-side view was that unemployment could be brought down only by increasing flexibility and mobility in labour markets, to remove 'frictions'. From a technological point of view this, however, carried other dangers; in particular that freely mobile labour markets and (downwardly) flexible real wages could reduce the incentive to undertake technological change, especially labour-saving technological innovation. In the long term, a pattern of reducing real wages as the prime response to increased competition or other constraints would be self-defeating inasmuch as it would fail to generate real economic growth. Equally, the role of aggregate demand for labour in Keynesian fashion was perhaps too hastily dismissed.

As noted in section III. 3.1. above, the role of labour demand however re-entered at a more micro or meso level through considerations of rising inequality, in particular the alleged 'skill bias' of technological change over these years. There we argued that there were changing patterns of skill requirements associated with new technologies, though somewhat more complex than a simple 'skill bias', with some reskilling but also some deskilling, albeit at different times in the technology lifecycle. The stage where major

productivity gains and any 'increasing returns' accrue comes later in this cycle. As pointed out, this suggests one explanation for the 'Solow paradox', and an important reason why productivity trends differ over time from technology trends.

However we also find support for some of the other explanations for rising inequality and unemployment during the final quarter of the 20th century noted in section III. 3.1. above. Alternative explanations that have been offered in the general literature include factors from international trade and more general arguments about 'governance'. Our studies from Poland in the MACROTEC project – and indeed our overviews of the historical evidence (von Tunzelmann, 2000) – indicate that changes in trade, e.g. linked to the opening of transition economies, do have differential effects on demands for skills, expressed in patterns at the industry level which do not seem accounted for by a simple 'skill bias' approach. Secondly, our more theoretical studies have indicated that broader institutional factors do play some part. In the Landesmann-Stehrer paper, one explanation tendered for the 'Solow paradox' comes from a Keynesian-Schumpeterian view of the importance of financial mechanisms for distributing the benefits of technical change at the macro level. If distributions are unequally allocated, then unemployment may be expected to rise. Although we have not pursued the point in our project, this could be linked to arguments that 'monetarist' policies alone can promote inegalitarian redistributions of income that in the end are also adverse for long-term growth.

Our argument is therefore that new technologies, and expanded spending on technological development, need to be geared into impacts on labour markets. In particular, the 'régulation' aspect of the régulation school argues that aggregate demand has to be aligned with such changes on the side of aggregate supply. However this line of argument ought to give equal attention to the developments in technology themselves. Until the late 1980s in countries such as France and the UK, as well as the USA and the Soviet bloc, big pushes in technology spending tended to be associated with 'mission-oriented' programmes spearheaded by governments in the RTD field. This was less evident in other countries where programmes were traditionally more 'diffusion-oriented', but around the mid to late 80s even the 'mission-oriented' countries switched emphasis. This was of course enforced by the collapse of communism in the Former Soviet Union, but it was almost equally pronounced in the other countries specified. Despite the attention paid to such missions as the Human Genome project (which itself now appears as simply a first step towards understanding biological processes), the dominant characteristic in the USA, especially, was a shift to decentralized, locally-organized and widely-diffused activities, partly supported by federal government subsidies. There seems to us to be some danger that developments towards a European Research Area such as the stress on 'integrated projects' in the Sixth Framework Programme have not yet fully

absorbed the lessons learnt within all of these leading countries in the past 15 years. Any expansion of R&D spending will have to give very careful thought as to how it is to be structured and diffused, and one significant dimension of this lies in the distribution of such activities in relation to availabilities of skills, particularly in relation to the ability to absorb outcomes into industrial and economic practice.

The rise of the 'national systems of innovation' approach (see WP1) has shifted the attention of innovation studies scholars away from the mere constituents of the national systems (which tend to be quite similar from one country to the next, although in varying proportions), towards the linkages among these constituents, which translate into some of the 'transmission mechanisms' we are seeking. The primary emphasis is on innovation and technological accumulation as learning/knowledge based processes, rather than information processes as in neoclassical economics. Within such learning processes, 'learning by interaction' is regarded as differing greatly as between countries and their associated national systems. The same argument extends to international systems of innovation – instead of costless 'spillovers', the direction and degree of *effective* technology transfer will depend on the orientation and the extent of cross-national 'learning by interacting'. Thus FDI, for example, may have specific or more general impacts on technological accumulation in the host countries, depending on such learning patterns. Crucial to successful technology transfer is the recipient country's 'absorptive capacity', and it is a basic premise of the seminal work of Cohen & Levinthal (1989, 1990) on absorptive capacity that it is augmented by 'learning by doing', that is by carrying out similar activities oneself. The implications for accession countries will be assessed in sections III. 4. and III. 5. below, but it is enough here to underline that this is a far cry from the passive and costless pattern of 'spillovers' envisaged by the new growth theory.

We therefore conclude that changes in political governance may be needed to overcome the adverse effects on inequality of technological change, and as later argued any adverse effects arising out of opening up trade and FDI. In that way we come back to the 'compromise' integrated view expressed at the start of this section. But full accounting will have to await the discussions in the sections to follow.

### 4. Matching economic policy and RTD policy: WP 4

The aim of WP4 was to study the impact of macro-economic *policies* on technology at the *national* level. The major expected outcome was specific country reports, and perhaps later some cross-country studies. Thus, WP4 is complementary to WP2, whose main objective is to come up with *quantitative* studies of the relationship between macro-

economic performance and technology at a more aggregate level. The *qualitative* character of WP4 encapsulates its principal contribution to the overall project, a contribution that has much greater importance for scholars who are not really convinced by the potential of econometric methods. To avoid an inconsistency of results, a strong analytical framework and set of guidelines had to be issued before detailed work could begin. WP4 was costed as being the dominant part of MACROTEC in terms of the resources devoted to it (70 person-months). Much of this work took place in Year 2 of the project.

Concerning the impact of macro-economic policies on technology one can distinguish between *direct* and *indirect* effects. As explained in the proposal for MACROTEC, the main effects of macroeconomic policies on S&T concern the *supply of technology*, the (*derived) demand for technology* and the *stability of economic environment*.

- The *supply effect* presumes that investment in technology is influenced (like all kinds of investment) by interest rates, bank credit to the private sector, firm taxation, and exchange rates (especially in the case of imports of capital goods). Interest rates are perhaps the most important variable here, and there is some evidence (Guellec and Ioannidis, 1997) that business sector R&D spending is sensitive to interest rate fluctuations. However, the above authors estimate that the lag of the influence of interest rates is 3 years. We have not found in the literature empirical evidence for the impact of other variables on technological investment, though see the comments in WP2 above.

- The *demand effect* of macro policies on technology has not been studied directly until now. What has been studied at length is the impact of demand fluctuations on technology, in the context of the "technology-push vs. demand-pull" debate. It is worth noting that most empirical studies published in the 1990s found that there is a significant impact of demand changes on different proxies for technology, like R&D spending, patenting, or number of innovations (Kleinknecht and Verspagen, 1990; Geroski and Walters, 1995; Hall and Mairesse, 1995; Guellec and Ioannidis, 1997; Brouwer and Kleinknecht, 1999). To our knowledge, the only recent empirical study that does not find a causal relation running from GNP variations (a proxy for demand changes) to R&D is that by Saint-Paul (1993). Still, under 'normal' conditions the main origin of demand fluctuations is economic activity itself (i.e. business cycles) rather than economic policy. Of course, it is possible to find examples of serious macroeconomic shocks brought about by economic policy, but such cases are characteristic of turning points in economic evolution (Thatcher's economic policy or transition economic reforms in CEECs). The major aim of

macroeconomic policy is to smooth out the business cycles; it is thus difficult to distinguish in a quantitative manner between the impacts of macro-economic policy and economic activity on technology. However, a more qualitative argument remains possible. For example, we can suppose that the fear of inflation prevented European governments from adopting a more effective anticyclical policy during the recession of 1992; thus arguably, the negative effects of the business cycle were not counterbalanced by appropriate macroeconomic policy.

- It was difficult to find empirical evidence about the *stability effect* of macroeconomic policies on technology, even if this seems plausible or logical. Inflation and exchange rates seem to be the most critical indicators of macroeconomic instability. For a discussion of the impact of macro-economic policies on long-run growth see the report for WP1, pp. 24-34. For a formal treatment of the relation between macroeconomic instability (inflation and exchange rates) and adoption of new technologies, see the paper presented by Brzozowski at the Vienna meeting.[3] Note also the possibility of serious trade-offs between the positive effects of macroeconomic stability and the negative effects of the instruments used to obtain it (rising interest rates and reduction of aggregate demand).

The indirect effects of macro-economic policies on technology are exhibited via S&T policies, production and consumption models, and cost structures.

- As explained in the first page of the proposal "the impact of specific S&T policies on technological development" is out of the scope of our project. However, it is rather obvious that different regimes of macro policy can have important consequences on the possibility of funding S&T policies and, consequently, in an indirect way, on technological development itself. For example, budget cuts influence technology through not only the aggregate demand reduction, but also the reduction of public funding for S&T. The above argument supposes that S&T policies have a positive effect on technological development. This seems to be a plausible hypothesis, even though concerning the public funding of private R&D there is contradictory empirical evidence (for a positive assessment, under specific conditions, at the level of OECD, see Guellec and Van Pottelsberghe, 1997).

[3] See also p. 53 of the literature survey ('The links between the business cycle and the innovative activity'): "Two arguments are put forward for explaining the negative impact of macro volatility (Aghion & Howitt, 1998) : it increases the option value of delaying irreversible R&D investment (waiting is a good option in these macro-economic conditions), and it delays the diffusion of new technological knowledge reducing the speed at which the various sectors learn from each other."

- In periods of rapid structural change, macroeconomic management can preserve or undermine the existing production (or consumption) model. The change or the preservation of the existing economic environment influences in turn the creation and diffusion of technology. Note however, that putting in question the previous model (thus accelerating the 'cleaning up' effects of the crisis) does not necessarily lead to the promotion of a new viable model. For example, supply-side policies in the 1980s obviously accelerated the end of the Fordist model of production and consumption, but they did not establish a new virtuous cycle of development. The same pattern applies a fortiori for transition policies in CEECs (Dyker and Radosevic, 1999).

- As noted in the proposal, "macroeconomic policy can have effects on the costs of resources and thus inducements to technical change" (p.4). Furthermore, macroeconomic policy can have divergent indirect effects on technology, depending on the cost structures of different sectors. This was taken up mostly in the work of Radosevic and Kutlaca within the project.

### 4.1. Targets and instruments

The MACROTEC project indicated in its original proposal that it would investigate a range of macroeconomic policies in terms of their impact on S&T, with a view to coming to some consensus about which policies or policy mixes were most suitable for supporting S&T. At its simplest, this was envisaged as coming down to a choice between macroeconomic policies directed mainly at the supply side as compared with those directed mainly at the demand side.

Before proceeding to our findings – which have been remarkably consistent in their results despite a wide variety of contexts and perspectives considered – the range of choices and the theoretical underpinnings need to be categorised more formally. In the second half of the 20$^{th}$ century, and especially in its final quarter, the choice between supply-oriented and demand-oriented macroeconomic policies turned into acute and often bitter conflict, not just among theoreticians but more broadly across the scene of practical policy-making.

The nature of the debate was structured by formalizations of economic policy by a Dutch school in the early 1950s, headed by Jan Tinbergen (e.g. 1952), joint-winner of the first Nobel prize in economic science. Into this school flowed two main streams. One was the resurgence of macroeconomic thought given by the Keynesian revolution, established primarily by Keynes' *General Theory* in 1936, which led into the widespread adoption of national income accounting during and after the Second World War. The second stream

for Tinbergen was the statistical revolution paving the way into modern econometrics in the 1930s, partly due to his fellow-Nobel laureate, Ragnar Frisch. Tinbergen combined these into the first major econometric models of the macro-economy and its evolution. It should be noted that Keynes and Tinbergen had a public dispute over econometric modelling of the macro-economy in the late 1930s, when Keynes argued that macroeconomic relations were too unstable to lend themselves to long-period analysis (Freeman has recently characterised their contrasting perspectives as 'vertebrate' and 'invertebrate', but Keynes was – as so often – being inconsistent since his *General Theory* rested partly on the assumption of a 'vertebrate', i.e. stable, consumption function). This debate has some consequences for our own approach, but other points first need to be developed.

Tinbergen outlined his basic argument about macroeconomic policy-making as follows. Policy was directed at a number of 'targets'. In order to hit these targets, policy-makers had available to them a certain range of 'instruments'. Generally speaking, the number of (effective) instruments had to equal the number of targets for all of the latter to be attained simultaneously. For example, if one target was full employment and another was price stability, and there was only one instrument to hand – say fiscal policy – then expanding this instrument to drive the economy towards full employment would make it more difficult to avoid inflation, i.e. infringe price stability. A second instrument – say monetary policy – had to be available to maintain price stability while expanding fiscal policy to achieve full employment. It will be noted immediately that three things minimally are required, even assuming enough instruments to be available to influence the number of targets. The first is that it is possible to distinguish targets clearly from instruments – in practice, the instrument sometimes becomes the target, as frequently occurred for the exchange rate. Secondly, we have to suppose that, once equality is achieved between number of instruments and number of targets, that both can be separated sufficiently into their constituents. That is, it was apparent when having only fiscal policy to hand that its deployment would affect both targets (of full employment and inflation rates) – once monetary policy is added it has to be possible to deploy it separately from fiscal policy so that it can get on with the job of maintaining price stability while fiscal policy looks after full employment. In practice it is often difficult to use them independently of each other. Thirdly, and most importantly, the instruments have to be powerful enough to reach the requisite targets under the above conditions.

A typical list of targets and instruments for governments of industrialized countries after World War II was as set out in Table 4 below.

**Table 4.** Targets and instruments for public policy

| Targets | Instruments | Examples |
|---|---|---|
| Full employment | Fiscal policy | Tax changes, public expenditure |
| Price stability | Monetary policy | Interest rates, monetary control |
| Balance of payments | Trade policy | Exchange rates, tariffs, quotas |
| Economic growth | Commercial policy | Competition policies, subsidies |
| Economic equality | Incomes policy | Wage freezes, education, regional |

On the Tinbergen principle, there should have been enough instruments (in the middle column) to attain the targets listed in the left-hand column. This is particularly the case since the 'real' number of instruments, hinted at in the number of examples given in the final column, greatly exceeds the number suggested by lumped-together headings such as 'monetary policy'. The actual record of macroeconomic policy-making, in complete contrast, is usually regarded as having been rather poor in terms of outcomes. There is much debate over whether the contribution of governments was even positive so far as these targets were concerned, much less whether it was substantial.

However in relation to targets and instruments, it was noted that:

- It is not easy in practice to distinguish between targets and instruments. For example, whether interest rates are instruments or targets depends on the specific context of the macro policy that is being implemented.

- The plea for a more detailed analysis of macro-economic policies also has its limits. Thus, the socio-political process by which (macro) economic policies are shaped, or the reasons for the success or failure of macroeconomic policies and their consequences on growth and employment, could not be studied at length in the context of this project.

- It is important to study not only the different elements or facets of macroeconomic policy but also macroeconomic policy as a whole. Certainly, the distinction between different macro policy regimes (e.g. expansionist vs. contractionist regimes) that succeed each other in historical time cannot but be based on a detailed analysis of the evolution of macro variables. Nevertheless, the identification of different macro policy regimes goes beyond the analysis of individual elements and presupposes an interpretative framework for the latter.

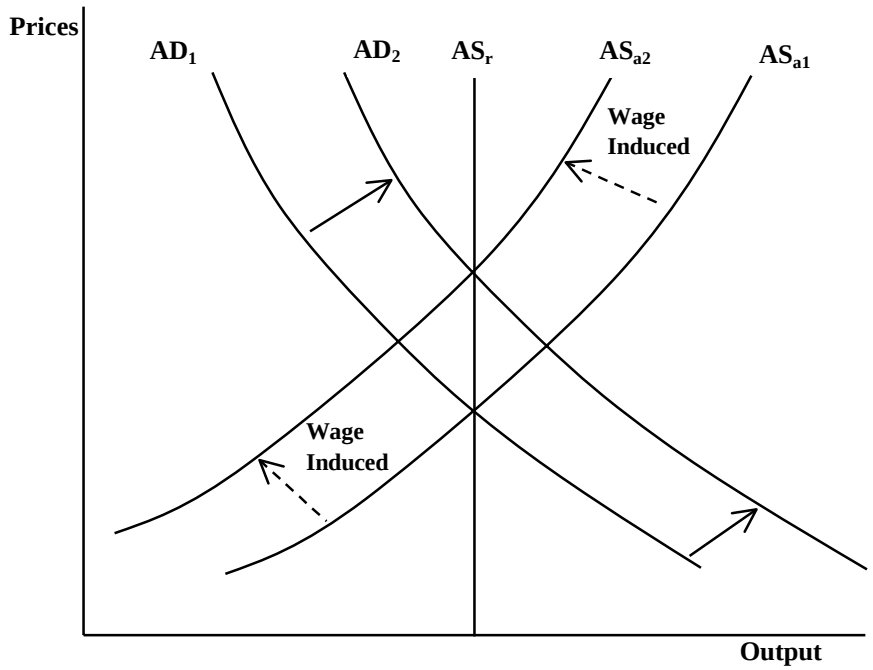
For the purposes of MACROTEC, our main interest in terms of targets has been in 'economic growth', for it is here that we would expect to see the main impact of technological change on the targets, but it is not possible to ignore other targets as well. For instance, the discussion of employment and skills in regard to WP3 immediately raises issues of 'full employment' and 'income equality'. In any case, our chosen topic is the impact of macroeconomic policies on S&T, which necessarily requires us to address the full range of instruments. To assess what policies might be used or modified to sponsor S&T more effectively, we first need to have some understanding about the limitations of policy within its own arena of supposedly guarding the macro economy. This was a main objective of WP4.

### 4.2. Limitations of current analyses of macroeconomic policy

According to the alternative line of argument being pursued here, increases of demand at micro and more generally at macro levels may be required to implement technological change in any effective way. However there has also been a serious loss of faith in the manipulation of aggregate demand as a means for promoting economic growth since about 1970. The primacy of aggregate supply over aggregate demand is reflected in the macroeconomic policies of the EU and especially in the 'Maastricht criteria' for joining the EMU.

The familiar arguments for a supply perspective run as follows. Assume first the existence of conventional aggregate demand (AD) and aggregate supply (AS) curves, relating price levels to output levels (see Figure 2(a)). These conventional curves are downward-sloping in the case of AD and upward-sloping in the case of AS ($AS_a$), with the latter representing diminishing returns, especially in the labour market since other productive factors such as traditional capital or 'technology' are taken as given. Now, an expansion of AD that raises the AD curve, e.g. through fiscal expansion, has the short-run effect of raising prices but also of raising output to some degree, along the given and upward-sloping $AS_{a1}$ curve. However this rests upon workers being 'tricked' into responding to increases in nominal wages – when they find that prices have also risen and their real wages have been reduced, they will bargain up real wages to restore them to their original levels. Once this has been done, prices will have risen but output will fall back to its own original level, as shown by the leftward shift of the AS curve to $AS_{a2}$, so all that has happened is a temporary rise in output and a long-term rise in inflation. In the long term, according to this view of 'adaptive expectations', the AS curve is vertical ($AS_r$) – prices rise from expanding AD but output does not.

**Fig. 2(a).** Induced shifts in Aggregate Supply Curves from wages

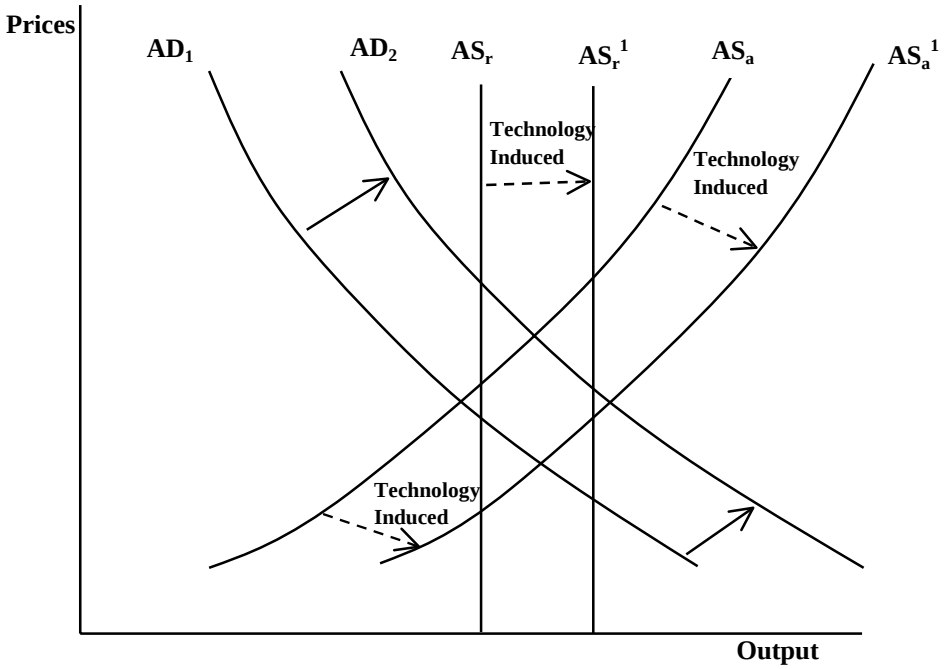



In the 'rational expectations' version of this latter argument, the effects on real wages are foreseen immediately – workers cannot be tricked even in the short term so the AS curve is always vertical, and expansion of AD is always self-defeating. The empirical evidence for changing rates of unemployment is not immediately compatible with the assumption of market equilibrium maintained in these views, unlike the emphasis placed upon it in Keynesian AD-led models, and is therefore explained away by (mostly unexplained) changes in the 'natural rate of unemployment'.

In this project we have adopted a different standpoint. We would contend that the *ceteris paribus* assumption underlying the AD/AS apparatus of Figure 2(a) is misleading. As has previously been recognised (e.g. Brown, 1987), an upward shift of the AD curve may generate an outward (downward) move of the AS curve through provoking an increase in physical capital formation (for example through the well-known 'accelerator'). This is what is indicated in Figure 2(b), shown by the outward shift of the $AS_a$ curve to $AS'_a$. We would here extend that proposition to other components of 'broad capital' besides physical (tangible) capital – to R&D especially, and in the longer term also to human capital. Depending on how responsive the AS curve is to expansion in AD, the price rise will be mitigated (including the effects of cost reductions from technical progress) and the output rise will be more than just temporary. Even if the AS curve is vertical in the short term, as in the 'rational expectations' viewpoint, there will be a gain of real output

and a diminution of the inflation effect (shown in curve AS'$_r$), albeit less than if the AS curve is upward-sloping.

**Fig. 2(b).** Induced shifts in Aggregate Supply Curves from technology




The empirical evidence indicating such induced shifts in the AS curve is outlined in the next section. A number of reasons have been provided by theorists for such a finding and we would suggest two broad explanations: first, the indications of 'demand-pull' as a determinant of technology from an empirical innovation studies perspective; second, the more economic point that the demand for technology is a *derived* demand, and ought to respond to market growth.

The case for a demand-pull mechanism was made most convincingly by Schmookler (1966), who was influenced by the dominance of Keynesian macroeconomic views at the time he was writing. Schmookler used evidence in patenting in several US industries in the late 19$^{th}$ and early 20$^{th}$ centuries to demonstrate a lead in time of investment (taken in Keynesian fashion to assess demand-pull) over patenting (the chosen measure of innovation). Moreover, Schmookler showed a synchrony across patenting fields in a selected industrial activity regardless of the specific technology considered; implying that a whole range of technologies were responding to similar causes, among which demand-pull seemed most plausible. Thus in railways, there were synchronous movements in patenting in locomotives, engines and boilers, fuel, rolling stock, wheels and axles, and rails, even though these came from a mixture of technological sources (different sub-branches of mechanical engineering, iron and steel, wood and coal products, etc.), and this would be because all were roughly simultaneously pulled up by surges of investment

demand. Schmookler did allow for some supply-push impact from technology to output – indeed this might explain the cycles he observes through a kind of multiplier-accelerator formulation, though this was not an issue he pursued (see Kleinknecht & Verspagen, 1990) – but his main stress was clearly on the primacy of demand-pull. This cross-sectional evidence therefore buttressed the time-series studies and highlighted the derived-demand nature of the demand for technologies, especially as investment itself could be seen as a derived response from the demand for output (von Tunzelmann, 1995: 7-10). Hence the sequence of supply-side stages from supply of science to output growth could be mirrored in the sequence of demand-side stages from output growth back to the demand for science.

What we are therefore putting forward is a compound of old Keynesian views about expanding AD with newer Schumpeterian views about the role of technology (a compounding which Keynes himself conjectured in his introduction to the *Treatise on Money* in 1930 but never pursued). This is *not* in contradiction to supply-side, monetarist views about macroeconomic theory, indeed it incorporates such views. Both Keynes and Schumpeter, after all, placed great emphasis on reasonable price stability. What it does contradict is the inferences about macroeconomic *policy* which are embedded in current EU stances. It is saying that in anything other than a very short-term view, current economic policy prescriptions may be inconsistent with the other main EU objective of promoting the competitiveness of the EU economy. Where that leads to in terms of alternative macroeconomic policies will be developed further in sections III. 5. and IV. below, though more tentatively at this stage.

One immediate issue, to which we will return in section III. 5.2., is the question of how much price stability? While the Stability and Growth Pact tends to assume the rate of inflation should be close to zero, there is in fact little evidence that moderate inflation is deleterious and may indeed be beneficial on balance. This proposition was formally established in a paper by Brzozowski (from partner no. 7), which suggests a curvilinear relationship of inflation to moderate levels having a positive growth impact and above that a negative one. Independently it has also been asserted in papers by the well-known American economist, George Akerlof, and colleagues (1996). The postwar record of western European countries – where there were no instances of hyperinflation once World War II was digested – actually indicates a slight but not highly significant positive relationship between the rate of inflation and the rate of economic growth (von Tunzelmann & Efendioglu, 2001). The evidence is more fully surveyed in the separate OECD papers noted above, with essentially similar results.

It has to be accepted that a significant part of this hybrid Keynesian-Schumpeterian approach remains underdeveloped as yet, especially where it has to do with an 'open economy' version of such a model. The prevailing post-Keynesian view on the open economy relies on export-led growth, but has little to say about the current importance of international flows of factors (e.g. FDI) or flexible exchange rates. The prevailing 'Schumpeterian' view about technology in an open economy is the so-called 'technology gap' approach, that differences in international trade performance across countries can be accounted for by differences in technology levels (the 'gap'), as well as differences in unit labour costs and in 'organization' (e.g. Dosi et al., 1990; Fagerberg, 1994). However in writings to date the technology gaps are often taken as givens, and the organizational 'gaps' are generally overlooked. As such, this does not represent a huge advance on supposing technology to be exogenous. We can, however, expand the horizon by envisaging technology levels (and concomitant organizational levels) to reflect differences in national technology systems, differences in technological 'regimes', and differences in national or supranational economic policies. That way, they can be 'endogenised' in a broader setting.

### 4.3. Transmission mechanisms at the macro level

A major issue that arises in this respect concerns the 'transmission mechanisms' (again to use the language of monetarist macroeconomics which a Schumpeterian approach might be expected to eclipse). These run between micro, meso and macro levels, and in section III. 2.4. above we have considered some of these mechanisms operating at the micro level of firms, while in section III. 3.3. we have referred to those operating between technologies and skills. At the same time, we might wish here to reject the monetarist presumption that the only need is to establish a secure microeconomic footing for macro-level deduction. Quite apart from the extreme artificiality of the axioms established for microeconomic analysis which immediately obliterate any possibility of deriving practical policy inferences, there seems to be just as much justification for the 'macro foundations of microeconomics' as for the monetarist 'micro foundations of macroeconomics'. What matters is the level at which behaviours are determined and decisions are accordingly made. The 'national system of innovation' approach implies that much behaviour in regard to technology is fashioned at the national (and indeed international) level, without disregarding the micro-level determinants and inducements (Edquist, 1997) – the same more broadly goes for the 'social systems of innovation' or equivalent 'national systems of production' viewpoints. From an economic rather than a technological perspective, this was of course the main message of Keynesianism, that the macro level in part drives other levels of action, though this message is often overlooked.

### 4.3.1. Public-private interactions in R&D

Complementarities between the public and private sectors within the national system in terms of conducting R&D may constitute one such transmission mechanism operating at the more macro level. The monetarist conception of R&D expenditure in this light parallels its view of other productive activities – that expenditure by the public sector 'crowds out' expenditure by the private sector, and as the latter has a higher level of business acumen, the former should wither away. In the RTD field it is crucial to distinguish between the *funding* and R&D and the *performing* of R&D. Comparing the EU as a whole with the US over the last quarter of the 20th century, both regions had similar proportions and trends in the sources of R&D funding. Industry and government sources contributed about 50% of the funding in the early 1970s, with the industry share rising to about 10 points higher by the later 1990s. The difference between the two regions lay primarily on the performing side: in both regions business performed a considerably higher proportion of total R&D than it funded, but in the US the overall share performed by business was consistently close to 10 points higher than in the EU. In other words, the US took much further the distinction between R&D inputs (funding) and outputs (performing), in the direction of letting business 'crowd out' the public sector – but only in terms of performing. Another way of putting this is to say that the extent of state (federal) subsidy for business R&D was substantially higher in the US, contrary to much popular opinion.

Over time, however, our cross-country studies of all the OECD countries for which we have acceptable data show few instances of countries in which any 'crowding out' appeared to occur as between public and private sectors in R&D, whether viewed from the side of funding or from that of performing R&D. From the late 1970s to the late 1980s, when R&D activity relating to ICTs rose to its height, indicators for both public and private sectors in both funding and performing increased. This was a natural reflection of the costs of developing new technological paradigms as already described. Our findings about the lack of crowding out, and indeed some evidence for positive 'crowding in' where public funding/performing raised rather than lowered private activity, are supported in a more general overview of such work by David et al. (2000). This is in a way good news for the Barcelona target, inasmuch as public funding/performing is usually easier for governments to raise than private activity, except that the complementary element in the target is for two-thirds of the increase to come from the private sector. Our considerations here suggest that the latter target may be still harder to attain than the 3% overall intensity, yet we would counsel the need to integrate the public and private activities, as the real message coming out of alignment considerations relating to 'national systems of innovation'. Moreover, as we found for the case of Poland,

particular macroeconomic policies may have asymmetric effects on technology inputs as opposed to technology outputs (productivity etc.).

### 4.3.2. Open economy interactions

Taking an 'open economy' standpoint, the accumulation of technology within a country leads to the attainment of the country's technological profile, and hence its technology gaps compared with other countries. On these grounds its 'comparative advantage' in terms of the basis for its activities in international trade is laid down. The international dimension thus provides a further macro-level transmission mechanism. We have seen above how the basis of comparative advantage is increasingly being defined by imported rather than domestically generated technology in the 'cohesion countries' like Spain and Greece, and in the transition countries since the early/mid 1990s. We have also observed that unless this FDI is intertwined with domestic capabilities the countries concerned will continue to be vulnerable; so, for instance, our studies show that Greece for too long relied on technology transfer at the expense of technology creation. A key issue is that FDI is being largely treated as a substitute for indigenous (domestic) technological capability rather than its complement, e.g. in Poland where domestic capabilities in many areas seem to have reached the point of exhaustion. In Bulgaria, we have some evidence that the macroeconomic policy of currency stability since 1997 has encouraged some growth in inward FDI but been associated with further declines in the country's own business-funded R&D. The emerging 'assimilationist' view of technological advance in catching-up countries emphasises that there have to be active domestic responses to FDI, in entrepreneurship, labour markets, and institutional arrangements, as the case of Ireland positively demonstrated. Relying on 'embodying' technology through raising FDI is not sufficient.

### 4.3.3. Impact of EU policies on transmission

For Greece, our studies indicate that more purposive use of the Structural Funds was probably more central to turning around the domestic economy than the conventional macroeconomic gains from its accession to the EU. The resort to Structural Funds raises well-known issues of potentialities for conflict between equity considerations and efficiency considerations. The Greek case – like the more convincing Irish case before it – does provide some support for the view that there does not have to be a direct trade-off between the two, though the use of the Structural Funds for innovation purposes remains somewhat inconsistent and indeed often controversial. What we can readily observe from both theoretical and empirical evidence is that rising inequalities and labour market hysteresis, both within and between countries or regions – fostered by the trends in

technological biases, trade competition and new governance modes outlined previously – can have deleterious effects on aggregate demand and hence on the demand-pull incentive to innovation. Fiscal policies may have to be designed to offset the more negative impacts of monetary and related policies on the innovation process.

### 4.4. Institutional change: cohesion and accession

The interrelationships between technologies and skills set out in section III. 3. (WP3) represent one important way in which expansion of R&D may run into rising obstacles imposed by shortcomings in linked requirements. The 'systems of innovation' approach however goes beyond questions of skills into broader linkages to the institutional set-up. Above we have witnessed the relationships derived by the 'régulation school'. The alternative 'new institutionalist' school of thought as developed by North and others equally draws attention to both 'organizations', i.e. formal structures such as banks, and 'institutions', i.e. rules and modes of behaviour, in underpinning economic growth. We have traced relationships over time between 'governance', i.e. "organizing collective action", and technologies over time as being a 'coevolutionary' one (von Tunzelmann, 2003) – structural changes in technological systems like that from electro-mechanical to information technology are matched by structural changes in modes of governance, from centralized giant firms towards decentralized networks of small firms, large firms and non-profit bodies including state apparatus. This transition too is a costly one, typically taking up to half a century to work its way through, and during which the rewards to introducing the new technologies may not appear to rise in proportion to the efforts made – the 'Solow paradox' in another form.

These transitions are necessitated at the micro/meso level of individual firms (etc.) and the interrelations among them. It is a major problem to shift from hierarchical top-down decision-making to effective use of bottom-up knowledge, not least because of the need to ensure a sufficiently skilled level of manpower engaged in the latter; without which the bottom-up decisions would of course be of little value. Changing the modes of behaviour in this direction is more than just a question of the right personnel, however.

These problems are exacerbated by any need to change behaviour at the macro (national) level. They are most obviously at their most acute in the 'transition' of countries of the former Soviet bloc, which built up a political system based predominantly on highly centralized decision-making and targeting. In such an environment the national system and associated national networks maintained an overwhelming power base. The system as a whole could not have run without the exercise of management through local enterprises, but the autonomy granted to the latter was very limited in theory, if wider in

practice. Global systems were of comparatively minor importance, being limited largely to exchanges among like countries of the bloc. R&D, among other functions, was entrusted to specialised organizations of various kinds which were supposed to meet their own centrally-defined targets: a purely supply-led system in which the needs of users (demand) were given very little consideration. Except in the military/defence field the system was highly unsuccessful and very wasteful.

The 'transition' process has almost entirely reversed these interrelationships (McGowan et al., forthcoming). The national systems with their attendant networks have largely imploded, leaving a near-vacuum. The R&D organizations and institutes, for one, while never greatly plugged into their users, have been left isolated and practically deserted. Global systems have eclipsed national systems as avenues for technology generation. The superiority of western technology, brought in through inward FDI, has swept all before it as a means for technology transfer. At the local level in recipient countries, there has been some upgrading of industrial sites through brownfield investment, though most commonly the western investor wants to shift fairly soon to greenfield locations. Certainly the western investor has displayed little if any interest in domestic R&D establishments, and indeed often a quite considerable contempt for them.

In our view it is crucially important to re-engage with internal sources of technology generation and adaptation. Naturally this does not mean going back to the discredited systems of the socialist era; instead it means orienting their pools of talent to a world in which knowledge interchange occurs among heterogeneous agents, all of whom have an active role in technological development, and in which external market demands drive the system. Our principal arguments for reconnecting these isolated domestic institutes have to do with the long-term viability of the national systems in the transition countries – without such reconnection the benefits from FDI may turn out to be once-for-all and bounded rather than acting as a spur to continuing expansion. However the viewpoint of meeting the Barcelona target provides a further incentive for re-engagement of indigenous RTD activity, in order to shore up the national 'absorptive capacity' as outlined above.

The experience of past accession in the 'cohesion countries' gives some grounds for optimism but also for concern. The major success story in this respect has been Ireland, which however joined the EU (then EEC) in the early 1970s (McGowan et al., forthcoming). In the 1980s, Ireland embarked on proactive policies, firstly to attract FDI into the country particularly in high-tech areas, and secondly – for rather different reasons – to raise educational standards within the country. Supportive internal fiscal policies and thorough exploitation of EEC funding possibilities (forerunners of the

Structural Funds) boosted these efforts. For a lengthy period the economic growth looked rather dualistic, with the lead taken by inward FDI from multinational enterprises, but in the end the fruits of the educational expenditures led to a recoupling with domestic industrial expansion. Irish growth became more balanced and even more of a 'miracle' to some in the 1990s. Many however believe that the chance factors involved in the Irish case limit its applicability to other accession countries (e.g. Salavisa, 2002).

Our studies of Spain after its accession in 1986 do suggest a pattern of change that has some similarities with Ireland. Before 1986, according to these results, technological change was largely led by domestic demand factors in the manner portrayed by the Keynesian-Schumpeterian model outlined above. After 1986 the technological lead passed to FDI from multinational companies. This had mostly positive impacts as the orientation of the FDI switched around the same time from targeting the domestic economy and low wages, to more emphasis on using Spanish investments as a springboard into the EU. Some problems however continued, including a split between the public and private sectors in the development process. The cases of Portugal and especially Greece were less positive in respect of utilising FDI. Greece received what were substantial quantities of FDI relative to its domestic industry, and these became the primary source of technological progress, but the spur to domestic industrial expansion was very limited. Greece benefited little from the opening of EU economies in terms of its exports and in exchange increased its technological dependency on those other economies. The situation was however rescued in the 1990s predominantly by the receipt of relatively large amounts of Structural Funds.

We conclude here that institutional developments have to undertaken alongside any expansion of more narrowly technological facilities in order for national economies to benefit. This is shown most starkly in the access to external technologies made possible by EU accession in the 'cohesion countries' in the 70s and 80s, and by opening up economies in the 'transition countries' in the 90s. The extent to which the technological 'spillovers' made possible by these developments provoked an internal technological response varied substantially from country to country. In Poland any 'Schumpeterian response' in terms of vibrant domestic companies is still being awaited, meanwhile the impetus of transition itself appears to be somewhat running out of steam. In Bulgaria the indigenous sources of technology have been almost totally bypassed, by an admittedly smaller quantity of FDI. Without a realignment between foreign and domestic technology it seems conceivable that expansion may not be sustainable; for example the FDI could move on to another country offering still lower wages as inducements. It seems clear that FDI requires more than a passive acceptance if it is to lead to sustainable

development – it needs an active domestic policy stance to align external with internal opportunities.

### 4.5. Country studies

#### 4.5.1. The structure and evolution of macroeconomic policy: Ricardian, Keynesian and Schumpeterian policy frames

Building on the work that has emanated from the 'régulation' school in France, the notion of 'social systems of innovation' takes into account other aspects of production and market-based systems as well as technology.[4] Such work describes various taxonomies of 'accumulation regimes', in which modes of production are aligned with varying degrees of success with demand structures; for example in classical 'Fordism', mass production had to be matched by awarding high wages for productivity gains.

Christian Le Bas & Christophe Salvat conducted a critique of the relationship between macroeconomic policy and S&T policy in France over the years 1981 to 1997. In the 80s, the main characteristic of the French system was the dominance of public spending on R&D, an important part of it being in conjunction with large firms and 'mission-oriented' in Ergas's terminology (Ergas, 1987). In macroeconomic policy there was a sharp shift from Keynesian expansion to stability from 1983, best described as 'competitive disinflation'. Disinflation was believed to lead to greater competitiveness, exports, growth and employment. This implied controlling domestic public spending. High interest rates restricted investment and growth when expansion was required, and the policy became counterproductive in the 90s. However the policies (including exchange rates) led naturally to the Maastricht Criteria and the formulation of the EMU. This was overrating the role of costs and prices rather than innovation, as well as penalizing investment. R&D intensity declined in the 1990s, with the proportion financed by the state falling (the latter partly due to declining defence expenditure). Therefore the link between macroeconomic policy and R&D investments was missing, despite the high importance of the public sector for R&D. Policies were Keynesian until 1983 and then Ricardian, rather than Schumpeterian. There has been some offset from the introduction of a tax credit to subsidize R&D spending by private companies. Overall the image of the dominant role of the state in the French model no longer applies.

[4] A similar and independent approach by members of the Macrotec team was couched in terms of 'national systems of production'.

**Table 5.** UK record in targets and instruments, mid-1970s to mid-1990s

| Targets | | Instruments | |
|---|---|---|---|
| Full employment | High unemployment, seen as a micro problem | Fiscal policy | Reduce taxes and expenditure |
| Price stability | Key objective, though inflation quite high | Monetary policy | Key weapon but targets consistently missed |
| Balance of payments | Assisted by oil but tending to deteriorate | Trade policy | Floating exchange rates, freer markets |
| Economic growth | Poor at first, then improving | Commercial policy | Privatization and intended liberalization, re-regulation |
| Economic equality | Steadily widening gaps | Incomes policy | Abandoned, freeing of labour markets, schemes |

The case of the UK was studied by von Tunzelmann (from Partner no. 1). In theoretical terms, the policies of successive governments over the postwar period until the 1970s can be interpreted as 'simplified Keynesian', built on the assumed supremacy of fiscal policy. However the real problems were external in origin, as the balance of payments remained a continual check on domestic expansion, resulting in frequent cyclical upturns and downturns known as 'stop-go'. These inhibited the development of any consistent technology policy, though both Conservative governments (through their Ministry of Supply) and the Labour Government of 1964/70 (through the Ministry of Technology it created) tried unsuccessfully to develop coherent policies. Kaldor himself was associated with an attempt to use taxation policy to influence structural change. This Keynesian model of course gave no solution for 'stagflation', and the coincidence of high inflation with no growth in the early 70s, and such a shortcoming paved the way for the rise of supply-side economics from the late 1970s. The situation of targets and instruments in this era can be classified as in Table 5 above.

Pursuing this structure, the government effectively stripped itself of most instruments for effective management of the economy, which came to depend almost exclusively on interest rates (which remained high in real terms). This left the country in a poor position to capitalise on the radical technical changes occurring in the manufacturing sector, though the encouragement to financial concerns led to more innovative strategies in the private services sectors. Privatization was seen as a solution to many problems if only through absolving the government of direct responsibility (and expense). Government policy for technology was seriously depleted of funds and suffered from erratic shifts of direction. Productivity rebounded in the later 1980s, but whether because of these policies or despite them is an open question.

Liagouras (from Partner no. 4) examined the case of Greece since 1975. The author argues that macroeconomic policy has had relatively little impact on the technological levels of the catching-up economy of Greece, because technological capability depends on absorptive capacity in relation to imported technologies (FDI, capital goods, licensing) rather than internal technological creation. Hence the inappropriately expansionist macro policies of the 1970s did not result in technological expansion, though the policies of stability aiming at EU convergence in the 1990s may have some relationship to better technological performance recently. Liagouras divides the period 1975/2000 in Greece into 4 sub-periods so far as macroeconomic policies were concerned, and compares their various characteristics. Against his general line of argument, he accepts that macro policies may have had an indirectly positive impact by stimulating a business environment of entrepreneurialism. Two points of note can be explored in subsequent work. Foreign trade policies appear to have had some effect (exchange rates), and there was a notable contribution from inflowing EU funds to growth in the 1990s.

Stanislaw Kubielas evaluated the relationship between macroeconomic policy and S&T policy in Poland over the transition period of the 1990s, which was characterised by mounting economic disequilibria and a breakdown of the inherited centrally planned S&T system. Kubielas noted that the targets for macroeconomic policy aimed primarily at ensuring internal and external balances, in particular in market equilibria like price stabilisation, or those of the private sector (savings-investment balance), government sector (government budget balance) and foreign sector (current account balance). Any policy orientation towards long-term growth and the RTD sector is secondary to these targets.

The 1990s in Poland may be divided into four periods. The first two involved a *Ricardian-type* adjustment, initially based on a fixed exchange rate and state-controlled wages, which harmed RTD though leading to an investment boom. As domestic savings failed to match the investment, the growth path became *Keynesian*, increasingly dependent on external sources (FDI) and exposed to external shocks. Keynesian decline ensued, ironically due to the hard monetary policy, which reduced the attractiveness of the country for foreign investors. Essentially Poland failed to develop a transition to a *Schumpeterian* type of growth, through neglect of the domestic base for technology and large reliance on FDI.

Technology indicators show that overall GERD failed to show much recovery, though R&D employment held up after transition. In effect, the technology transfer from abroad through FDI meant that over the 1990s domestic S&T policy played but a minor role in the development of the RTD system. Though this helped solve the problem of insufficient

domestic savings relative to investment opportunities, it created another problem of current account imbalance, which led to reactions in monetary policy, thereby both destroying domestic demand and deterring FDI. The recent economic slowdown and problems with the current account deficit as well as a dramatic decline in the investment rate may be regarded as obvious symptoms of the country's exhausted technological potential due to largely neglected S&T and innovation policies over the past decade.

A further study of Poland, coordinated by Kubielas and incorporating work from colleagues Brzozowski, Kozlowski and Jasinski from Warsaw (Partner no. 7), began by examining macroeconomic policy in the country since 1990, and is discussed in more detail in the next sub-section in regard to international dimensions. For reasons set out there, the authors argue that a new transition towards Schumpeterian growth based on raising domestic technology levels had become imperative from 1998. They proceed to relate the economic policy changes to changes in S&T - initially the two were independent but were forced closer together partly through declining government budgets. Despite various policy documents aspiring to the contrary, science policy and innovation policy remain largely disconnected today. The authors detail the Polish 'national system of innovation' and demonstrate the ways in which R&D cutbacks followed from the declining state budget. Through rigidities, government expenditure on R&D after early transition (see WP2) behaved anti-cyclically, but was not offset by sufficient rise of BERD. The negative correlation of GERD intensity with GDP growth is in line with the empirical findings by von Tunzelmann and others in cross-country studies as reported for WP2. Faster growth in the mid-90s is probably explained by technology transfer and FDI, a proposition that is supported by the figures collected by the authors on the 'technological balance of payments' (again, see WP2). The authors conclude by trying to estimate the direct and the indirect impact of macroeconomic policies on the RTD sector. Tightening monetary policy (e.g. high real interest rates) is negatively correlated with productivity growth. The authors conclude that S&T policy drifted along in a neutral way, with the increasingly restrictive macro policy of recent times doing little to provide more positive demand-side impacts.

The study of Hungary 1990-2000 by Attila Havas showed that stabilization dominated macro policy rather than long-term views of STI, and stabilization itself was attenuated by 'softening' any attempts at austerity. In Hungary, mandatory central planning had been set aside as early as 1968, and there was considerable experience with a market economy. Equally the rigid division of labour in S&T was relaxed, e.g. through universities conducting some R&D, though cooperation in technological development remained unusual. Despite the exposure to markets, consumption in 2000 was lower than in 1989 (although GDP was higher), and there was greater unemployment,

insecurity, inequality and corruption. More positively, western institutions now prevail in most activities, and the private sector accounted for 90% of GDP by 2000. After a decline in the early 90s the economy bounced back in the later 90s. Investment is now a higher proportion of (higher) GDP than in 1989, and the sudden rise in unemployment to 1993 had halved by 2000. As in Poland there were about 4 phases of macroeconomic policy during the 1990s – alternately tightening and loosening. Tight macro policies reduced government funding of R&D but had less effect on foreign firms. Microeconomic adjustment has been costly and painful, with a dualistic pattern emerging between large foreign-oriented (and often owned) firms and indigenous SMEs. The picture of R&D is gloomy, with GERD falling from 1.61% of GDP in 1990 to 0.67% by 1996 and staying down to 1999, but as companies need R&D to survive in a more open trade environment, they increasingly rely on foreign technology. No systematic S&T, innovation or industrial policies have been implemented since the early 1990s: the Szechenyi Plan of 1990 marks a modest step, but understanding of modern views of innovation is limited. An implicit S&T policy emerged in the later 90s, mainly emphasising networks and academia-industry cooperation. Links between macroeconomic policies and S&T policies have not been made.

Rossitsa Chobanova and Nick von Tunzelmann combined their resources for an assessment of macroeconomic reforms on R&D in Bulgaria. They found that macro policies since the opening of the economy had been rather complacent until a severe crisis in 1996/7, when a currency board was set up to control galloping inflation. Since then there has been stability rather than much growth, but at least an end to decline as in the early 90s, when real per capita GDP appears to have more than halved. The composition of foreign trade has shifted radically with openness and reorientation to the EU. According to the data, there was not only a big fall in GERD, but a marked decline in business-performed R&D, with the latter emerging especially at the time of currency reform. However FDI appeared to increase about the same time, probably because of greater economic stability. Hence stabilization had offsetting technology effects of reducing BERD but raising inward FDI, though the data perhaps need greater scrutiny. Bulgaria's main problem is how to indigenize the new technologies made accessible by greater international openness.

### 4.5.2. Internal and external policies

A paper by Fonfria and colleagues (from Partner no. 9) takes up the more specific question of trade policies, corresponding to the section on that subject in the literature survey for WP1. Fonfria et al. use a technology gap approach to understanding changes in world market shares, and argue that changes in technology gaps in turn derive from

different national systems of innovation, different technological regimes, and different national policies. They review the literature, both theoretical and empirical, as part of the process of defining their model. They then proceed to considering the possible effects of macroeconomic policies (trade policies via the real exchange rate, industrial policies and demand policies) on competitiveness, which cover both the technology side of the technology gap formulation and the costs side. The study is conducted for four countries (France, Italy, Spain and the UK) in two markets (Western Europe and Latin America) for 20 sectors over the period 1987/96. A 2x2 matrix of competitiveness shows the broad situation, with the first cell ('rising stars') show growing market share in a relatively growing sector, and so on. Spain and Italy have a large proportion of 'rising stars', while France and the UK have large numbers of 'retreats', that is falling markets shares of relatively contracting sectors. The patterns relate to technological levels of the respective sectors. The authors show a positive sign on the variable for unit labour costs in Latin America (this is the 'Kaldor paradox' result) but no significant effect for Western Europe. R&D has its strongest effects for the less technology-intensive countries of Spain and Italy. The real exchange rate most influences exports from Italy. Industrial policies as measured by subsidies seem to have more effect on exports to Latin America, with little impact on high-tech sectors. Demand is positive and significant for all four countries in Western European markets, though less so for Latin America. Overall the analysis shows the differences in impact as between different sectors (high-tech vs. low-tech), different markets, and different policies. Demand, assessed through the size and dynamics of markets, plays a crucial role.

Still relating to Spain, Isabel Alvarez, Joze Damijan (Ljubljana) and Mark Knell set out initial results of their econometric investigations in their paper, "Technology transfer and productivity spillovers in Spain during the 1990s". They made use of a detailed survey carried out annually in Spain for the years 1991/9 to distinguish foreign-owned from domestic firms. The main aim was to detect productivity spillovers and any impact on Spanish absorptive capacity from the FDI. FDI boomed in Spain with growing openness from 1959 and especially with accession to the EU in 1986. However there is some macroeconomic evidence of a growing importance of domestic sources of R&D from the 1990s. One issue to be resolved in the econometric tests is that foreign-owned firms are larger than domestic, so any impact could be more a size effect than a foreign effect. Labour productivity and export propensity are higher in foreign firms according to the raw data (disaggregated by industry), but not R&D intensity, patenting, innovating or support from public R&D funds. Different econometric estimators produced different results in terms of spillovers, with some suggesting positive spillovers and others negative. The estimation work is still in progress.

George Liagouras and Yannis Caloghirou, with Artemis Koukounari (LIEE, NTUA, Athens), discuss the opening up of Greece, a country where it seems plausible to argue that imported technology is a very significant component of technological accumulation. They argue for four phases of macroeconomic policy in Greece since 1975, though this should be seen in the longer perspective of Greek political and economic change since WW2, when the economy grew rapidly but was over-protected (though with strong incentives for FDI). Political cycles after 1975 meant that macroeconomic policy was either too expansionary or too contractionary at the wrong times, though Greece's entry into the EU in 1981 may have added to the problems because of readjusting from over-protectionism. The best performance came in 1994-2000 when Greece satisfied the Maastricht criteria and joined the EMU. However inflows of financial support from the EU, along with semi-legal immigrant labour, also drove economic performance in these recent years. FDI appears to be a dominant factor in growth, but direct evidence is problematic because of changes in data acquisition. The role of policy changes may have been overstated in the previous debates.

In section III. 4.5.1. we noted for the case of Poland, a study by Kubielas and colleagues from Warsaw (Partner no. 7). In examining macroeconomic policy in the country since 1990 they found that, after the immediate post-communist period, there was a fall in government spending and tax revenues relative to GDP, with the relative government debt falling to levels not greatly different from western Europe. Foreign debt fell especially sharply through renegotiations, and in terms of trade policy the zloty appreciated until 1996. Economic growth peaked in 1995/7. From 1998 the government adopted a modernization strategy in public spending, directed towards accession to the EU, though in the short run growth and the exchange rate fell back. Exchange rate policy influenced monetary policy, which was anti-inflationary from 1990 - successfully so, as the inflation rate declined monotonically from 1991 to 1999 (though real interest rates thereby rose). The impact on S&T is examined by dividing the transition period into 4 sub-periods, corresponding to those set out in section III. 4.4.1. High growth in the mid-90s was driven by investment, but domestic savings could not match this expansion of investment so FDI had to rise sharply to meet the gap. With external shocks such as the Russian crisis of 1998 contraction set in, even though FDI was maintained. It was these considerations that led the authors therefore to argue that a new transition towards Schumpeterian growth based on raising domestic technology levels had become imperative from 1998, as already detailed.

### 4.5.3. Technology policy and the state in S&T

A paper by von Tunzelmann updated earlier work conducted jointly with Ben Martin (Partner no. 1), to investigate the relationships between public expenditure on R&D and private expenditures. Some scholars argue that government R&D 'crowds out' private R&D, others believe that there may be positive complementarities between them. The present authors use data for 22 OECD countries, both as single-country relationships and in panel-data format. To obtain overall averages, least-squares dummy variables (LSDV) methods are recruited to supply the many missing values over the period 1963/95. Econometric estimation uses ECM methods to try to establish causality and also differences between short-term and long-term relationships. The short-term interrelations between industry-funded and government-funded R&D vary considerably across countries, but only one country (Japan) gives any suggestion of a 'crowding-out' type of relationship. In the longer term, the results support complementarity rather than crowding-out. Links to aggregate growth for industry-funded (or industry-performed) R&D and for government-funded (or government-performed) R&D are thus similar.

## 5. The impact of supranational macroeconomic policies: WP 5

### 5.1. The context of supranational European policies

There are four main areas of EU policy, implemented since the founding of the Common Market, that can be considered as being of a macroeconomic nature: integration of markets for goods and services, of which enlargement represents a special case; exchange rate stabilisation and monetary integration; and regional development. Here we cover only issues that arose in our investigations for the MACROTEC project. It should be noted that the switch of emphasis from harmonisation to Open Methods of Coordination during the project changed our objectives rather substantially in this section.

While the actions implemented to assure market integration and regional development are not, strictly speaking, macroeconomic policies, they have important primary effects of a macroeconomic nature. For example, market integration leads to increased trade within the internal market, and FDI increases as firms adapt their organisational structure to take account of the enlarged market. Trade and FDI flows are also altered between the internal market and outside markets. As for regional policy, Structural Funds programmes are the means by which interregional transfers take place between Member states. This mechanism should result in a fiscal stimulus to Member states and regions which are net beneficiaries, since, in principle, Structural Funds support cannot be used to reduce national spending commitments (i.e. the 'additionality' principle).

### 5.1.1. Economic integration and enlargement

Economic integration comes about through the elimination of barriers that segment national markets for goods and services. An initial phase of economic integration began in 1958 with the establishment of a common market (Treaty of Rome), completed in 1968. A second phase of economic integration began in 1987as a result of the Single European Act, involving the elimination of:

- cost-increasing barriers (differences in technical regulations between Member states, frontier delays due to customs procedures and related administrative burdens, such as collection of statistics, verification of technical requirements, etc.);

- market entry restrictions (restrictions on service transactions, in sectors such as transport, financial services, etc., restrictions on competition in public purchasing, etc.);

- market-distorting subsidies and practices (public aid, collusion and abusive use of dominant positions by private firms).

Enlargement of the internal market occurred with a first wave of admissions in 1973 of Denmark, Ireland and the UK, followed by Greece in 1982. In 1986 Spain and Portugal joined. In October 1990, the reunification of Germany brought the eastern Länder into the European Community (a *de facto* enlargement of the internal market). Further enlargement took place in 1995 with the accession of Austria, Finland and Sweden to the European Union. The future accession of new states to the European Union (in particular those in Eastern and Central Europe) will lead to a further enlargement of the internal market. Most of our investigations concerned either southern Europe (the Mediterranean countries) or the imminent accession of the candidate countries.

### 5.1.2. Exchange rate stabilisation and monetary integration

The regulation of exchange rate fluctuations within the Community was managed from 1972 through the European Monetary System (EMS). Member states had to remain within a ±2.25% margin of fluctuation in relation to the dollar and reduce fluctuations between their respective currencies. This mechanism was superseded in 1979 by the Exchange Rate Mechanism (ERM), serving the same purpose of exchange rate stability through closer monetary co-ordination.

A first step towards monetary union (Maastricht Treaty, implemented 1st November 1993) was the reinforced co-ordination of economic and monetary policies of Member

states, along with the monitoring and guidance of their economic and monetary policy, with particular regard to budget deficits and price stability. This was followed in 1994 by the second step which involved the establishment of the European Monetary Institute (EMI), measures ensuring the free movement of capital between Member states, and the introduction of five 'convergence criteria', by which the readiness of Member states for participation in the single currency was to be judged.

The launch of the single currency and the irrevocable fixing of exchange rates of the participating countries (Euro zone) took place on 1 January 1999, managed by the European Central Bank (ECB), with the primary commitment being to price stability. The institution is responsible for the setting interest rates and conducting foreign exchange operations. At some time in the future the size of the Euro zone is likely to increase as countries currently opting out and accession countries join the monetary union.

There are a range of other policies with somewhat related indirect effects that we did not investigate, e.g. fiscal harmonisation, regional policy.

The above supranational policies produce macroeconomic impacts at the level of individual Member states, which are likely to have repercussions on the demand and supply of technology, on economic structures, expectations and uncertainty, and ultimately national S&T performance and the effectiveness of national S&T policies. Cause and effect linkages between policies initiated at European level and national S&T performance are highly complex.

### 5.2. Results of the studies of the project

The results developed in WP4 carry implications for policy-making by the European Commission. An obvious one is that policies aimed at supranational macroeconomic stability through meeting the Maastricht criteria, emphasising the supply side of the coin, could have unintended negative consequences on the demand side for technological progress and hence growth. This may have deleterious effects on the accession countries as they aim to meet the acquis for the accession process, an outcome which already seems to have appeared in Poland. On the other hand, the consonance between output growth (as the driver) and productivity growth is more pronounced in the medium term, while that between output growth and technological change is ambivalent in the short run and probably strongest in the long run (however our findings are at present somewhat contradictory on this point). Thus if the stabilisation policy does achieve its object of permitting controlled expansion thereafter, its effects could turn very positive. Secondly, the introduction of 'open methods of coordination' as an EU strategy may permit greater sensitivity of response at the level of the individual 'national system of

innovation'. The very variety of those national systems as underpinned by our research indicates the importance of this consideration. Thirdly, as the study of Greece in our WP4 shows, one should not forget the potentially galvanising effect of inflows of EU funding for inducing local technical change.

Overall, our specific findings confirm our presupposition that macroeconomic policies and S&T policies are too disarticulated across the countries we survey, and there is a need – most powerfully in the catching-up countries – for much greater coordination between them. The work detailed below provides particular evidence for this general policy conclusion. We find that raising intangible capital intensity, through R&D, human capital formation, etc., does have positive effects on growth, as the conventional argument maintains, but that the payoff may be rather disappointing relative to expectations in the short to medium term. Shifting course to a new technological paradigm such as the 'knowledge-driven economy' may be expensive in the medium term, and governments need to look further into the long term for sustained gains. It is understandable that the development of supportive policy instruments at macro and micro levels may become frustrated by the slowness of the process, but the necessity for them nevertheless remains, as the alternatives appear far worse.

Ioanna Kastelli directly assessed the impact of joining the EU on the Greek economy, covering the period from the Affiliation Agreement of 1961 to full membership of the EMU in 2001. The economy grew rapidly to 1975 but then under-performed until 1995 and a new growth spurt. The 1961 Affiliation required the dismantling of the highly protected Greek tariff system by 1984 but even as late as 1995 tariffs remained high as a proportion of the total import value on some products. Until the late 1980s there was more effort to maintain the status quo e.g. through state aid rather than to restructure. The decline of protectionism and of state aid from the late 80s corresponded however with a deterioration in economic performance. State policies to attract FDI and technology transfer to Greece date back to 1953 and the resulting FDI has been highly significant for the Greek economy. Most was directed at penetrating the Greek market though there was some expansion of exports. However the domestic technological base was given little consideration until the late 80s. GERD is low relative to GDP though boosted by the EU, but the business sector contribution to R&D and its interaction with university R&D are very low. CIS surveys show some increase in innovative activity during the 1990s but Greece is second worst after Portugal in the EU. For the 10-15 years before the late 90s, austerity policies had seriously constrained state involvement in technological accumulation. From the late 80s, however, EU initiatives (Framework Programmes, Structural Funds) came to have a significant influence and partly offset internal austerity. Structural Funds reached 5% of GDP in 2000 and 14% of GFCF. But

even in the EU's RTD arena there is some indication, e.g. from the EUREKA projects, that Greek firms failed to transfer in all of the potential benefits.

In work subcontracted from SPRU (Partner no. 1), Radosevic argued that integration of the CEECs dominates the policy agenda of EU enlargement. Policy integration is assumed to lead to industrial integration. On the contrary, he contended that "Although market integration is a necessary objective of enlargement, it is in no way a sufficient condition of dynamically efficient outcomes for an enlarged EU." Not attending to industrial upgrading through integration of production and technology as well as of markets may instead lead to increased marginalization and lack of cohesion. The macro and micro levels of integration themselves need to be integrated. Radosevic shows in one of his papers how FDI, often treated statistically as a measure of integration, comprises many different types of activity with differing implications for micro-level integration.

As noted above, our work on European supranational policy mixes did not proceed as far as we had originally intended. This was partly due to time pressures, but more due to the reorientation of EU policies within the time-span of the MACROTEC project. Even so, our overall work concerning the need to integrate supranational policy as between macroeconomics and technology is seen as a major contribution to the policy debate, and this is what we develop next.

## IV. CONCLUSIONS AND POLICY IMPLICATIONS

There was an impressive convergence of views about policy implications in the course of the MACROTEC project. The most evident case of this convergence relates to the switch of emphasis from the supply side to the demand side. This is easier to comprehend in the policy sphere than in the analytical sphere, because macroeconomic policy arose in the original form of Keynesian-style 'demand management'. The analytical side, where the main heritage of orthodox economic analysis is the largely supply-driven neoclassical model, has been set out in some detail in relation to WP2. In the neoclassical model, growth is driven by the supply of factor inputs and a residual item originally attributed to (exogenous) 'technical progress'. Our own analytical work, as highlighted previously, aims to gives equal weight to the more heterodox views which would pay attention to the demand-side causes of growth, or often both sides. In this format, technical progress is endogenised as a response to the growth of output or as a feedback from it, representing a leap beyond the partial endogenisation of the 'new growth theory'.

### 1. Macroeconomic policies and the supply side

In policy terms, there are a number of ways in which we might expect to see macroeconomic policy helping to drive (or obstruct) technical progress, and hence the active effects of S&T policies. The orthodox supply-driven one looks at the role of costs and prices, as briefly set out in the EU's 1995 *Green Paper on Innovation*, and this has been the primary channel of impact entertained by governments of EU Member states since the 1970s. The lowering of unit labour costs for either unskilled or skilled workers may be expected to increase profitability, and more widely competitiveness in international trade. However it may act as a disincentive to labour-saving technical change, and hence to industrial 'upgrading'. This reservation is regarded by some as practically important in some intermediate economies, such as Portugal and some of the accession countries (as the contribution of Pereira-Mendes at the Athens meeting stressed), and possibly also in the UK after the breaking of trade union power in the 1980s. Further consideration of the effects operating through skilled labour were pursued in WP3.

Alternatively, reduced costs may affect the cost of capital, either tangible or intangible. Our empirical studies generally showed the importance of physical capital, especially in the catching-up countries (increasingly provided through FDI etc.). However in the more advanced countries our data also show a clear shift from physical to human capital as a proportion of GDP over the last quarter-century, and linked to the ICT revolution etc. Our work suggested that there may be some negative relationship between the real rate of

interest, as a rough measure of the cost of capital, and the relative decline of physical capital investment. However this also implies an unexpected positive relationship with the relative rise of R&D (intangible investment), contrary to the Green Paper's predictions.

Djuro Kutlaca and Slavo Radosevic conducted a summary analysis of cost factors for Central and East European countries (CEECs) at a sectoral level. In line with the original MACROTEC research proposal (see section III. 1. above) they argued that the same macro policies would have different impacts depending on the cost structure of different sectors. They assume that sectoral cost structures are approximately the same across countries for financial and technological reasons, and that technology also determines the rate of investment within sectors. These assumptions are roughly verified by examining the coefficients of variation of cost breakdowns in 6 CEECs. However there is some influence of differing levels of development, and the cross-country similarities are greater for large cost elements than for smaller, probably because of macroeconomic policy effects. The 'macroeconomic regime' is constructed as a composite variable based on 5 indicators: interest rates, inflation, exchange rates, budget deficit, and the current account. The hypothesis to be tested is that greater stability of the macroeconomic regime leads to deeper changes in industrial structure, but the finding is that the relationship is not too close. The best outcome appears to be an 'accommodative' macroeconomic regime, as a compromise between economic stability and the need for industrial transformation. Some impact of macro policy stability is also observable when products are distinguished into simple vs. complex, but structural uncertainty appears to be a key determinant.

Through the overall impact on prices, inflation has been widely seen as a deterrent to growth in the advanced industrial countries since the Second World War. The precise mechanisms through which this operates, and the scale of the effects, are however in some dispute. It is widely accepted that too high a rate of inflation will reduce and perhaps destroy the incentive to innovate. The more controversial issue is what happens with regard to low rates of inflation. Here, our studies at both theoretical and empirical levels have suggested that some positive rate of inflation may be beneficial for technology. Combined with the observation about hyperinflation, this suggests an inverted U-curve for the relationship between inflation and innovation. At what point this curve reaches its maximum is empirically significant but difficult to pinpoint. Our study of Poland, and a more casual reference to the case of Iceland where high rates on inflation did not seem to obstruct strong performance of the real economy, suggest that the maximum point may be higher than often thought. This in turn suggests that the Maastricht criterion of targeting a zero rate of inflation is almost certainly too restrictive;

the current UK target of 2.5% per annum (at the time of writing being under-achieved) may be better, yet even this may be too cautious in some environments. While inflation in isolation may be an evil, taking its cure too far may do more harm than good. This opens the door to more expansionist fiscal and other policies.

**2. Macroeconomic policies and the demand side**

Our principal new findings therefore relate to the increased attention we have paid to demand-side influences, as already intimated on many occasions. The findings are very consistent across countries and levels of aggregation, though they are – like the effects of inflation – by no means clearly understood. In country after country we find that aggregate demand impacts on technology are at least as powerful as the orthodox converse relationship, and this shows up as well in our econometric work using cross-country data.

This promoted an interest in our study of searching for the 'transmission mechanisms' which, on an analogy with supply-side economics and monetarism, might explain how aggregate demand impulses work their way through the economic system into raising technological levels. Our focus on macroeconomic conditions limited the attention we could divert to this issue, but some conclusions could nevertheless be drawn. One key area of transmission highlighted in our research already has been the impact of aggregate demand on new firm formation at the more micro level, as shown in research by the Lyon team. Independent but confirmatory research in WP3 by the MERIT team shows that skill upgrading comes about to a large extent through establishing new firms. Also confirmatory is the work from the Warsaw team which shows how macro-level demand expansion has encouraged the growth of higher quality output.

Work on the different arenas of public policy, e.g. monetary, fiscal, incomes, or trade, and the balance between governments' revenues and their expenditures, has begun but remains an item for further development. We have collected some data to analyse the impact of different types of public expenditure (e.g. defence, education, health, social security, R&D), but our specific studies to date are insufficiently diverse or consolidated to draw general conclusions, other than in the area of trade and FDI which we come back to below.

We do however find areas of positive impact from public expenditure. Fears that public spending may 'crowd out' private spending, e.g. in relation to R&D, appear to be often rather exaggerated. On the contrary, negative effects of tight macroeconomic policies appear to have restricted, or largely curtailed, R&D activities in countries like Hungary and Bulgaria. However we would not advocate unlimited expansion of the public purse. In

Poland, the hard budgets associated with fiscal responsibility have coincided with better technological performance, though there has been some tailing off in more recent years.

Equally, traditional Keynesian policies of boosting demand through budgetary expansion are of limited use unless they can be oriented to productive purposes, as Keynes himself well recognised. Here this means calling forth not just underutilised supplies of existing resources but in the end new supplies of hitherto unexploited resources. Fiscal expansion for its own sake is not exonerated in our analyses. For the case of Greece, the NTUA (Athens) team show that macroeconomic policies that were 'inappropriate' for their economic context, e.g. through being expansionist when the country could not afford it, or being unduly austere when growth was urgently needed, also probably had little positive impact on S&T. The era of 'hard budgets' in Poland has been more successful than pre-transition days of 'soft budgets' – one way in which hard budgets can be reconciled with some expansion is through setting quid pro quo targets for technology or production or export deliverables. What is needed is not a crude Keynesian apparatus but a new hybrid of Keynesian and Schumpeterian policies in order to call forth the interdependencies between supply and demand, as argued in the final section below.

Thus, while our findings point to the neglected but often dominant role of impact through the demand side, at the same time they do not take a crude post-Keynesian line that expanding public-sector demand will increase technological performance and thereby growth. The important point here is the need for complementarity with private-sector domestic actions. In a catching-up context, it is again the 'absorptive capacity' of the country, as outlined in the 'national systems of innovation' approach, that primarily dictates the technological response. Force-feeding expansionary demand without attention to micro-level responsiveness – and perhaps accompanying policies – will be little better than crude inflation. This exemplifies why it is crucial to trace the 'transmission mechanisms'.

As spelled out in section III. 5.2, these results carry strong implications for policy-making by the European Commission. An obvious one is that policies aimed at supranational macroeconomic stability through meeting the Maastricht criteria, emphasising the supply side of the coin, could have unintended negative consequences on the demand side for technological progress and hence growth. This may have deleterious effects on the accession countries as they aim to meet the acquis for the accession process, and our evidence detects some signs of this already. These have to be weighed against the potential gains from the stabilisation policy in the medium to longer term, working their way through output growth to productivity growth in Kaldorian fashion, for which we also find some empirical support. Moreover, the shift from harmonisation to 'open methods of

coordination' as an EU strategy may all a greater flexibility of response at the level of the individual 'national system of innovation'. However our evidence for Greece indicates that the policies may produce little if they are not backed up by inflows of resources, probably on a scale larger than currently planned under the accession process.

We can but reiterate that macroeconomic policies and S&T policies are invariably disconnected across the countries we survey, and there is a need – most powerfully in the catching-up countries – for much greater coordination between them. Raising intangible capital intensity, through R&D, human capital formation, etc., does have positive effects on growth, as the new growth theory maintains, but that the payoff may be rather disappointing relative to expectations in the short to medium term. This is mainly because shifting course to a new technological paradigm such as the 'knowledge-driven economy' may be expensive in the medium term, and governments need to look further into the long term for sustained gains. In this report we have drawn special attention to two factors drawing out and attenuating the productivity gains from technological change, namely the enhancement of skills and the need for institutional change. These in our view help account for the 'productivity paradox' or 'Solow paradox' of recent decades.

Our perspective on the Barcelona target of raising EU R&D intensity to around 3%, with two-thirds to come from private sources, is very much framed by these considerations of complementarity. As neo-Schumpeterians, we have a prior sympathy for aiming at such a target. However we also consider that its benefits will be greatly reduced, and the target itself probably become unattainable, unless due attention is given to the complementarities we have been describing, particularly those between aggregate demand and aggregate supply.

In terms of the current core issue in the EU of compatibility between the Barcelona target and the Growth and Stability Pact, all our evidence suggests that inflation is not injurious to innovation and some inflation is probably beneficial, as noted above. This does not invalidate the widely accepted view that too high a rate of inflation will reduce and perhaps destroy the incentive to innovate. It is claiming that, while inflation in isolation may be an evil, taking its cure too far may do more harm than good. This opens the door to more expansionist fiscal and other policies.

## 3. Towards a Schumpeterian macroeconomics

It is clear that both demand-pull and supply-push (technology-push) influence the path of technological progress, and the MACROTEC project has aimed to demonstrate that both aggregate demand and aggregate supply policies have had major impacts on aggregate technology efforts. This has led us, in our wrap-up meeting at Brussels and subsequent publications, to outline a case for a new 'Schumpeterian macroeconomics', in which Schumpeterian views about the role of innovation on the supply side, duly endogenised, can be folded into Keynesian views about the macroeconomic demand side. We have put more emphasis on the demand side than on the supply side in this document for two broad reasons: first because it is so often neglected especially in macroeconomic debates (for example the EU's own *Green Paper on Innovation* in 1995 mentioned only the effects of supply-side policies on innovation); and second because supply-side policies in isolation can have negative consequences for innovation if pursued to their logical extreme. We would stress that our approach throughout would be one of 'and' rather than 'or' – one of promoting complementarities rather than replacing with substitutes. Thus we have indicated how in analytical terms an aggregate demand (AD) strategy can itself impact upon aggregate supply (AS) and thereby generate real gains in technological accumulation for the growth of economies. We have focused mainly on fiscal rather than monetary policies as the means towards proactive AD strategies, not least because under EMU individual nations largely abandon any possibility for pursuing distinctive monetary policies, but there is some scope for differences in budgetary policies.

While the details of what the Schumpeterian component may consist of remain somewhat tentative, it seems clear that an element of his 'creative destruction' may be involved. The current round of renewed soul-searching in the EU over the Common Agricultural Policy may be a case in point, but it extends too to the use of Structural Funds for non-agricultural purposes. At the same time, we would more vigorously stress the point that a dichotomy between high-tech and low-tech as the strategic choice for industry is misconceived. For one thing, if countries crowd into high-tech industries the gains will be driven down through competition and diminishing returns; in any case it is blindingly obvious that such a strategy is not viable for most countries because the technology gap to be bridged is far too wide. Our main point is however more constructive: that by distinguishing technologies as 'inputs' from products (goods plus services) as 'outputs', we can readily envisage strategies whereby countries preserve their traditional strengths in particular product markets, but aim to produce those more traditional products using new technologies and new skills. So an existing strength in a particular food or drink item

or a particular ceramic design/process could be capitalised upon by bringing these new technologies and skills to bear upon them. Given the stage in the technology lifecycles that we have outlined above for ICTs, biotechnology and the like, they have reached the points of applicability that make such scenarios perfectly realistic (though this would not have been true 20 years ago). We thus point more towards 'creative accumulation' than 'creative destruction'; though in the same breath it needs to be stressed that the former implies change just as much as the latter.

This then makes a case for enhancing R&D across the whole spectrum of productive activities, from agriculture through manufacturing to services – the last of these especially in view of its ever-growing predominance in GDP. High-tech activities under the OECD definition account for only about 3% of EU GDP, so even a doubling of these will make only a minor difference to overall growth rates. There is also empirical evidence from the OECD databases that broader change has been occurring in a modest way over recent decades as witnessed in sectoral growth rates of GERD and BERD, though the levels of RTD activity remain very disparate across sectors. On the latter grounds, the obstacles to inculcating an RTD-oriented behaviour in the low-intensity sectors are evidently much greater than in sectors with high R&D intensity. This reinforces the case for institutional reform to be set alongside the quantitative expansion of R&D activity.

Such institutional reform should, in our view, be aimed at promoting the requisite complementarities. This goes beyond the standard encouragement of networking to 'aligning' the existing multiplicity of networks. The kinds of expenditure that may be augmented by additional R&D should be tailored to areas promising real long-term productivity growth. By 'real' productivity growth we mean extra productivity coming from extra output, rather than that (likely to be only temporary) from slashing inputs. Often such real productivity growth comes from doing more in a given period of time, that is through economies of speed to save time. Thus productivity per person-hour rises through reducing the 'hours' required to produce the existing level of output rather than reducing the number of 'persons'. This has powerful implications for the employment effects of the suggested policy changes, as detailed in WP3 above. It also implies a very direct 'transmission mechanism' whereby greater demand for output feeds back into greater need for process innovation to supply that increased output. Nor should we overlook the speed-up in technology itself and in product development, which as the employment literatures indicate tend to have positive impacts on total employment.

In order to maximise learning possibilities, it is crucial to take the labour force on board as part of the technological mission. Getting people to work faster is, *ceteris paribus*, less likely to induce pain than throwing large numbers of them out of work. Technology all too

often raises fears of unemployment, so the compensating mechanisms described in the theoretical literature to offset this effect must be made to work, other than where the case for creative destruction is overwhelming (Vivarelli 1995). It has to be recognised that the pattern of skill development over the past quarter-century has been exclusionist and inegalitarian. As the technology lifecycle progresses this should reverse itself in ways implied in section III. 2.1. above, but it may not do so entirely unaided. Over the long term, we have suggested that education responds to demand even with long supply lags – strategies of 'building education ahead of demand' (to use the phrase Schumpeter originally applied to the US railroad network) may have worked in parts of East Asia, but gearing training programmes etc. into effective demand seems more likely to succeed.

In addition to the complementarities between technologies and skills, our studies suggest the fostering of links between public and private RTD efforts. The large 'mission-oriented' projects of the third quarter of the 20$^{th}$ century seem to have given way to more 'diffusion-oriented' strategies even in the countries which most utilised them, but there seems to be room to go further. Studies of US technology policies since the late 1980s suggest a gulf between rhetoric and reality, with rhetoric placing the emphasis on large-scale, pre-competitive public-sector activity and the reality on small-scale, widely diffused, near-market activity. Although it falls outside our brief, there must be some concern that some elements of the current Sixth Framework Programme appear to reflect the US rhetoric and not the reality, though other elements seem better founded.

Since we explicitly excluded the operation of specific technology policies as ways of raising RTD spending from the scope of the MACROTEC project, we cannot offer new evidence on how to effectuate such a rise via specific public policy measures in private funding of R&D. Many countries are of course moving towards R&D tax credits and similar fiscal or other measures, with such a goal in mind. Our evidence is instead directed at the broader context of providing the incentive of greater opportunity through increased demand, and at establishing or reinforcing the institutional structures, especially the networks, that underlie such activities; because we feel that these warrant at least equal attention, and also because of the stress on the private-sector contribution in the Barcelona target.

Similar concerns relate to other factor inputs. As just mentioned, Schumpeter himself referred to laying down the US transport infrastructure ahead of demand. Whether this was historically the case is another question (Fishlow, 1965), but the key role of provision of infrastructure continues to the present day. Along with that goes the key role of capital expenditure, and Schumpeter's works in actuality devote much more space to capital than to technology. Repeatedly he stresses the need for innovation in financial

practices, envisaging such developments as we would now term venture capital for underpinning innovation in industry. The EU itself, along with international organizations such as the EBRD and World Bank does of course tackle the provision of finance for infrastructure. As with the US railroads, sharing of the burden between the public and private sectors may again become necessary, and the two are being cautiously interlinked by present-day governments through 'private finance initiatives' and the like. The main concern here is that, while again spending for its own sake is clearly most inadvisable, undue respect for the budgetary ratios in the Maastricht criteria may deter investments with positive long-term payoff. The English saying 'penny-wise, pound-foolish', that saving a small amount of money today may be very costly later, appears to be an appropriate description of the 'savings' on infrastructural maintenance and investment in the name of monetarism in the UK in the 1980s.

What we do rather consistently find in work carried out so far are substantial effects from externally oriented national policies, in regard to both trade (e.g. the comparative study of Spain and three other countries by the Madrid team) and FDI (e.g. the work on Poland by the Warsaw team). These appear to be most pronounced for catching-up or 'intermediate' countries. The relationships between technology and these external policies appear to run in both directions, from technology to trade and vice versa. Our principal finding is however that external impacts depend upon internal activities, in particular the need to generate 'absorptive capacity' to take advantage of any favourable external conditions. FDI by itself may not be enough, as work from the WIIW team shows.

Much of our study has therefore been directed at 'open economy' versions of the putative Schumpeterian model for macroeconomic policy, an area which we consider particularly underdeveloped in the theoretical literature. Here we are primarily considering again the inputs rather than the outputs side of the production processes – the international movements of technology, skills (human capital) and physical capital rather than trade in products (goods and services). The general presumption is that accession will lead to a rise in FDI into the accession countries; though whether this will come primarily from the old EU member-states or from outside is less immediately obvious (Spain after 1986, for instance, experienced a surge in extra-EU sources of FDI). Such FDI will embody new technologies and new business practices, which in themselves help advance the host countries. The main issue, though, is whether such FDI and the embodied technologies and skills are complements to or substitutes for indigenous technologies and skills in these host countries. The evidence from the earlier 'cohesion countries' is mixed – the most positive impact was (eventual) complementarity in Ireland, but in Greece the situation was more or less simple substitution for a long period. The bulk of our evidence

for the transition countries to date unfortunately suggests mainly the latter. We see this as a serious threat to the long-run viability of the transition economies. The national innovation systems of the countries need rebuilding, especially in the direction of realigning them with supranational and global systems, in order for the benefits of FDI to be fully realised. In no way is this a zero-sum game: interacting with improved domestic resources could easily enhance the returns obtained by multinational companies. But a new public-private interaction needs to be forged.

## V. DISSEMINATION AND EXPLOITATION OF RESULTS

Dissemination has been maintained throughout the project, and became especially urgent in latter stages of the project as the significance of policy implications became clearer. We are grateful for the assistance of DG Research in this process. We were also able to draw extensively on the channels provided firstly by our Steering Committee, and secondly by our User Panel (for membership see Annex 4). The User Panel in particular was deliberately chosen to reflect a balance of policy-makers and industrial decision-makers.

A list of the published outputs is given in the bibliography, while Annex 1 lists some of the conference presentations made outside the project. In addition, two of the meetings of MACROTEC were used to draw in related participants who were not members of the project, while in the final meeting there was a constructive interchange with officials from DG Research.

The original proposal promised that we would search for publication of the outcomes in a special issue of a refereed journal, and the name of the *Revue d'Economie Industrielle* was suggested as a possibility. We have now secured this special issue, which will go to press later in 2003. It includes 5 papers from the MACROTEC project, which were chosen on the grounds of being more oriented towards a combination of theory and empirical work.

The foreword to the work reads as follows:

> While economists are familiar with the potential impacts of technological change on economic performance and economic growth, the reverse link as to how economic behaviour at the macro level impinges upon technological change has been largely neglected. Any full account of the nature of economic change at the macro level must consider both lines of causation. Equally policy-makers need to take account of the demand-side effects from macroeconomics to technology as well as the conventional supply-side effects in the opposite direction. The studies in this issue argue that the links running from macroeconomics to technology are at least as strong as the converse.
>
> The project therefore investigates to what extent macroeconomic and S&T policies are mutually compatible, and how (in)compatibilities between these two areas of policy affect employment, growth and technical change. The papers from this issue combine quantitative

analyses of macroeconomic performance and technology with new lines of theoretical investigation. We finally suggest new policy approaches (using a Schumpeterian framework) which should integrate macroeconomic and S&T policy in order to promote technological growth and structural change (exit and entry of firms, emergence of new activities).

Three main topics are dealt with: the impact of the macroeconomic context on technological activity by firms, the relationships (coevolution) between macro performance and technological change, and the main characteristics of a Schumpeterian Macropolicy.

Contents:

P. Llerena: Introduction to theories of the relationship between macroeconomic behaviour and technological change.

C. Le Bas: Demand growth as a determinant of R&D expenditures: a multi-sectoral, multi- country analysis.

M. Landesmann, R. Stehrer: Technology diffusion, international competition and the global deflationary bias.

A. Jasinski: Public policy and technical change in Poland, 1989/99.

N. von Tunzelmann: Towards a Schumpeterian macropolicy.

As regards the country studies, plans are under way for the publication of a book by Edward Elgar, which would focus on the country studies, both in cross-country comparisons and individual differences. We expect to be able to announce this book as forthcoming later in the summer.

All papers remain accessible on the MACROTEC website.

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## VII. ANNEXES

### 1. Publications resulting from MACROTEC

*Partner no. 1 (SPRU, University of Sussex)*

Djuro Kutlaca

'Industries, costs and macroeconomic regimes in central and eastern European countries: towards stylized facts' (with Slavo Radosevic), paper submitted for publication to Cambridge Journal of Economics, August 2002.

'Information Technology for the knowledge-based economy', INFO, May-June 2001, IX(3): 83-85 (in Serbian).

'Information Technology - another successful industrial revolution - but when, where and how much?', INFO, November-December 2001, IX(6): 88-94 (in Serbian).

Nick von Tunzelmann

Technological Change and the World Economy (commissioning editor), four-volume series, Edward Elgar, Cheltenham (forthcoming).

The Emerging Industrial Structure of the Wider Europe (ed., with F McGowan and S Radosevic), Routledge, London, 2003 (forthcoming).

'Towards a Schumpeterian macro-policy', forthcoming in Revue d'Economie Industrielle.

'Historical coevolution of governance and technology', forthcoming in Structural Change and Economic Dynamics.

'Technology in postwar Britain', in R C Floud and P A Johnson (eds): The Economic History of Britain since 1700, 3rd edn., Cambridge University Press, forthcoming.

'Technological systems and comparative economic systems', in P A David and M Thomas (eds), Economic Challenges of the 21st Century in Historical Perspective, Oxford University Press / The British Academy, forthcoming 2003.

'Comments from the MACROTEC project on the "Barcelona target" to raise R&D intensity in the EU to around 3% of GDP', for European Commission, DG Research, July 2002, 19 pp.

'Network alignment and innovation in transition economies', Economic Thought, 3, 2002, pp 39-67 (in Bulgarian).

'Investment, technology, growth and employment in postwar Europe: short-run dynamics and long-run patterns' (with Ü D Efendioglu), in P Petit and L Soete (eds), Technology and the Future of European Employment, Edward Elgar, 2001: 46-77.

'Technology generation, technology use and economic growth', European Review of Economic History, 4, 2000: 121-46.

*Partner no. 2 (Université de Lyon II, France)*

Christian Le Bas

'The effects of the Single Market programme on productivity growth - international and intersectoral analysis: what we learn from a neo-Kaldorian analysis', Centre Walras working paper, 2002.

'French macroeconomic policy and S&T systems: evolution and interlinkages (1981-1997)', Centre Walras working paper, 2002.

'Demand growth as a determinant of R&D expenditures: a quantitative study at the sectoral level', Forthcoming in Revue d'Économie Industrielle, 2003.

'What does a Schumpeterian policy mean?' Centre Walras working paper, 2003.

'Technological natality, firm innovative persistence, sectoral innovative performance and international technological specialization' (with S. Négassi), submitted to the Cambridge Journal of Economics.

'Is the "death of distance" argument relevant?: agglomeration economies and information technology activities' (with F Miribel), Centre Walras working paper, submitted to Industrial and Corporate Change.

*Partner no. 3 (MERIT, University of Maastricht, the Netherlands)*

T Dunnewijk, 'The National Innovation System and macro-economic performance in the Netherlands 1950-1998', Merit/Infonomics Report, 2002.

A van Zon, 'Induced skill-biases in technological change and asymmetries in employment perspectives', MERIT Report, 2002.

A van Zon and M Sanders, 'On growth frontiers and labour market policies', MERIT Report, 2002.

Mark Sanders, 'Technical change and the demand for labour', PhD thesis at Maastricht University, chs 1 and 4.

*Partner no. 4 (Vienna Institute of International Economic Studies, WIIW)*

Michael Landesmann and Robert Stehrer

'Evolving competitiveness of CEECs in an enlarged Europe', Rivista di Politica Economia, 2002, 92(1): 23-87.

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'Technology diffusion, international competition and the global deflationary bias', forthcoming in Revue d'Economie Industrielle.

Mark Knell

'How important is trade and foreign ownership in closing the technology gap?: evidence from Estonia and Slovenia', TIK working paper, Dec. 2002.

Partner no. 5 (LIEE, National Technical University of Athens)

Y Caloghirou, G Liagouras and A Protogerou, 'Exploring mismatches between higher education and labour market in Greece', European Journal of Education, forthcoming.

*Partner no. 6 (IEBAS, Budapest)*

Attila Havas

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Rossitsa Chobanova

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**An1. Conference presentations**

(other than MACROTEC meetings)

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Fonfría, A, Díaz de la Guardia, C, Álvarez, I and Granda, I, 'Tecnología y comercio: un análisis de los factores explicativos del comercio español de manufacturas', IV Congress of Economic Policy, University of La Laguna, 2002. Published in IV Jornadas de Política Económica, pp. 182-97.

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Havas, A, 'Innovation and innovation policy for competitiveness and cohesion: transition, accession and cohesion of Central European countries', SEGERA conference on Innovation in Europe: Dynamics, Institutions and Values, 8-9 May 2003, Roskilde University, Denmark.

Havas, A, 'Does innovation policy matter in a transition country?: the case of Hungary', 10th EADI General Conference on EU Enlargement in a Changing World: Challenges for Development Co-operation in the 21st Century, 19-21 September 2002, Ljubljana.

Havas, A, 'Policy challenges and options for CEE countries' Conference on Technological Innovation and Globalisation: Implications for Intermediate Developed Countries", ISCTE,23-24 October 2003, Lisbon.

Kutlaca, D., 'University-Industry relations - key for successful national innovation systems and mystery for transition economies', 2nd RECORD Conference: University-Industry Relations, the Centres of Excellence in the universities of the accession countries, Budapest Proceedings of the RECORD Thematic Network, Budapest, 3-4 October 2002.

Kutlaca, D. 'University for knowledge-based economy', VIII Scientific conference: Technology, culture and development: Global and local in technological and cultural development - Yugoslavia in Europe, with special theme: Modernization of higher education system in Yugoslavia, Kotor, August 19 - 24, 2001, proceedings pp.141-56.

Kutlaca D. 'Science and technology: public attitudes and public understanding', IX Scientific conference: Technology, culture and development: Serbia and Montenegro on their way to European Union – Cultural and technological determinants of quality of products, services, jobs and life in Serbia and Montenegro, Palic, September 10 - 14, 2002, proceedings pp. 210-20.

Landesmann, M, 'Trade and FDI integration in an Enlarged Europe', High-Level Seminar on Regional economic co-operation: the European and Asian experiences, European Central Bank, Frankfurt, 15 April 2002.

Landesmann, M, 'Enlargement and convergence', Brussels Economic Forum, Brussels, 2-3 May 2002.

Landesmann, M, 'Structural features of economic integration in an Enlarged Europe', Economic Commission DG Economic and Financial Affairs, Brussels, 11 September 2002.

Landesmann, M, and Stehrer, R. 'International integration, catching-up and the role of FDI', European Trade Study Group (ETSG) Conference, Kiel, 13-15 September 2002.

Landesmann, M, 'East-West European integration: trade and productive adjustments in an enlarged European Union', Fundación Ramon Areces, Madrid, 11 November 2002.

Landesmann, M, 'Structural modelling of the dynamics of international integration and catching-up', Annual Workshop on Structural Change and Economic Dynamics, Bologna, 22-23 November 2002.

Liagouras, G., 'Economic policy versus growth regimes explanations of economic performance: the Greek economy during the period 1975-2000', EAEPE 2002 Conference: Complexity and the Economy. Implications for Economic Policy, 7th -10th November, Aix-en-Provence, France (oral presentation based on the Macrotec paper).

Liagouras G., 'Economic policy and performance of the Greek economy during the period 1975-2001', Proceedings of the 9th Sakis Karagiorgas Conference on Social Change in Modern Greece, Athens, 2003 (in Greek).

Stehrer, R and Landesmann, M, 'Technical change, effective demand and economic growth', Conference on Old and New Growth Theories: an Assessment', Pisa, 5-7 October 2001.

Stehrer, R, 'Technical change, effective demand and economic growth', International Schumpeter Society Conference, Florida, Gainesville, 29 March 2002.

Stehrer, R, 'International integration, catching-up and the role of FDI', International Input-Output Association (IIOA) conference, Montreal, 9-15 October 2002.

von Tunzelmann, N, 'Network alignment and innovation in transition countries', SEGERA conference, University of Roskilde, May 2003.

von Tunzelmann, N, 'Knowledge accumulation, networks and ICTs: evidence from traditional industries in Central and East Europe' (with D E Yoruk), SSEES, University College London, April 2003.

von Tunzelmann, N, 'Network alignment and innovation in transition economies', Bulgarian Academy of Sciences, Institute of Economics, Sofia, March 2002.

von Tunzelmann, N, 'Generating regional systems of innovation', University of Castilla-La Mancha, Cuenca, December 2001.

von Tunzelmann, N, 'Historical coevolution of governance and technology', ECIS conference on The Future of Innovation Studies (plenary lecture), Eindhoven, September 2001.

von Tunzelmann, N, 'The supranational perspective: the European Union and its role in innovation in Europe' Six Countries Programme, 25th Jubilee Conference, Stockholm, January 2001.

## 2. Meetings of MACROTEC

### Lewes meeting, April 2000

Representative of all of the contractor institutions met for a kick-off meeting at Lewes, Sussex, GB, on 15 April 2000, organised by the coordinator (Partner no. 1). This was a change from the original plan, which was to involve the principal coordinator visiting all partner institutions. It was felt that, as there was some delay in starting the project for administrative reasons, this meeting would be more time- and cost-effective.

### Vienna meeting, January 2001

In place of the separate workshops outlined in the original workplan (see Annex), it was considered to be much more efficient to have meetings of all partners at regular intervals, since most partners had an interest in most of the WorkPackages, and there was considerable overlap between the subjects. The first general workshop was thus held at Vienna on 12-13 January 2001, hosted by WIIW (Partner no. 5). Representatives of all partners attended. The discussions reported on work to date in a mostly informal manner.

### Athens meeting, May 2001

The first annual meeting was held at Athens on 4-5 May 2001, hosted by NTUA (Partner no. 4). The occasion was more formal than at Vienna, with presentations of written-up work. Representatives of all partners attended, along with Peter Fisch from the European Commission, and invited speakers from Portugal (Vivaldo Pereira-Mendes) and Yugoslavia (Djuro Kutlaca, who subsequently joined the team on a subcontract basis).

### Madrid conference meeting, March 2002

The fourth meeting of the MACROTEC project was held on 1-2 March 2002. The meeting was organised by Antonio Fonfria and Isabel Alvarez (Partner no. 9), and was held at the Instituto Complutense de Estudios Internacionales, Campos de Samosaguas, Universidad Complutense de Madrid. This meeting took the form of a Conference, with invitations to outside participants being posted on our website and elsewhere. In addition to members of the MACROTEC team, papers were given by Jose Molero (Vice-Chancellor of UCM), Isabel Salavisa (Dinamia, Portugal), Andrew Newell (Economics Dept, University of Sussex), Andrzej Jasinski (Unievrsity of Warsaw), Fulvio Castellacchi (TIK, Norway). The main lines of investigation reported in the 12-month report had been filled out and given much more empirical and econometric confirmation. Comparative work was found to be

proceeding successfully, but even more interesting was the strong convergence of findings across countries. In addition, the incorporation of policy perspectives and EU frameworks had been further addressed.

**Final wrap-up meeting, Brussels, July 2002**

The final meeting consisted of MACROTEC members plus invitations to DG Research and other policy-makers located in the vicinity, and was held as stipulated in Brussels, in South-East England House, directly across the Square de Meeus from DG Research. This was organised by the coordinator (Partner no. 1), and held on 3-4 July. The meeting took the form of summary presentations, with a particular orientation towards policy implications. It was agreed that the coordinator would write a report aimed at the Barcelona target issues for circulation to EU policy-makers as soon as possible.

**Agendas for relevant meetings follow.**

Work agenda for the Athens meeting, 4-5 May 2001

*4 May, pm, 2 sessions*

1) WP1: Literature survey and analysis

   a) Extensions to the first draft (Llerena, LeBas)

   b) Additional perspectives (Kubielas, Fonfria, others)

   c) Remaining gaps (von Tunzelmann)

2) WP2: Quantitative analyses of macroeconomic performance and technology

   a) Statistical analyses of macro performance (Knell)

   b) Statistical analyses of technology (Knell, Patel/von Tunzelmann, others)

   c) Country overviews of data:

      i) Poland (Kubielas, Socha etc.)

      ii) Hungary (Havas)

      iii) Bulgaria (Chobanova)

      iv) Greece (Liagouras, others)

v) Spain (Fonfria, Granda, Heras)

vi) France (LeBas)

vii) Netherlands (Dunnewijk)

d) Structural change (Knell, others)

e) Causal relations and methods (Warsaw, von Tunzelmann)

*5 May, 4 sessions*

3) WP3: Macroeconomic performance, skills and employment

a) Overview of the issues (Meijers)

b) Linking to macroeconomic issues (van Zon, or substitute)

c) Data for the theoretical model (Sanders)

d) Updating the Warsaw model (Brzozowski)

e) Skills in CEECs (Landesmann, Stehrer, in absentia)

f) Other case studies (Havas, Liagouras, others)

4) WP4: Macroeconomic policies and technology at the national level

a) General approach (Liagouras)

b) Indicators for macroeconomic policies (Liagouras, von Tunzelmann, etc.)

c) Country overviews:

i) Poland (Kubielas, Jasinski, etc.)

ii) Hungary (Havas)

iii) Bulgaria (Chobanova)

iv) CEECs (Radosevic, in absentia)

v) Greece (Liagouras)

vi) Spain (Alvarez, Fonfria)

vii) France (Longeau, LeBas)

d) International and cross-country comparisons (Fonfria)

e) Emerging common patterns (discussion)

5) WP5: Impact of supranational macroeconomic policies on technology and struct. change

a) An analytical framework (LeBas)

b) Identifying impacts in the Lyon model

c) Accession and Southern Europe (Fonfria, Kastelli)

d) Accession and Eastern Europe (discussion)

Agenda for Madrid Conference, 1-2 March 2002

*Friday 1 March*

1415: Jose Molero (Vice-Chancellor, Univ. Complutense de Madrid), 'Industrialisation and internationalisation in the Spanish economy' (invited address)

1445: Michael Landesmann & Robert Stehrer (WIIW, Vienna), 'Technical change, effective demand and economic growth'

1530: Isabel Salavisa (Dinamia/ISCTE, Portugal), 'Growth, innovation and specialization patterns – history and institutions in intermediate countries' (invited address)

1630: Andrew Newell (Sussex) & Mietek Socha (Warsaw), 'The rising non-manual wage premium in Poland' (invited address)

1715: Mark Sanders with Adriaan van Zon (MERIT, Maastricht), 'Constructing a dataset for the analysis of the skills-technology-employment nexus'

1800: Christian Le Bas (Lyon) & Syoum Négassi (Antilles Univ.), 'Technological natality, firm innovative persistence, sectoral innovative performance and international technological specialization'

*Saturday 2 March*

0915: Fulvio Castellaci (TIK, Oslo), 'Cumulative growth and technology gaps – the empirical evidence for Spain, 1964/97' (invited address)

1000: Isabel Alvarez (Madrid), Joze Damijan (Ljubljana) & Mark Knell (WIIW, Vienna (TIK, Oslo, and UNECE), 'Technology transfer and productivity spillovers in Spain during the 1990s'

1030: Theo Dunnewijk (Infonomics, Maastricht), 'Macro economic performance and R&D expenditure of large and small firms in the Netherlands 1969 –1998'

1115: Christian LeBas & Christophe Salvat (Lyon), 'French macropolicy and S&T systems – evolution and interlinkages'

1145: George Liagouras (NTUA, Athens), 'The different impact of macroeconomic policy on imported technology and RTD system in Greece, 1975-2000'

1215: Ioanna Kastelli (NTUA, Athens), 'The impact of supranational macroeconomic policy on technological development – the case of Greece'

1400: Stanislaw Kubielas & Michal Brzozowski (Warsaw), 'Macroeconomic performance and technology performance: panel data analysis – Polish case and cross-country comparisons'

1430: Djuro Kutlaca (Mijhalo Pupin Inst., Belgrade) & Slavo Radosevic (SSEES, London), south-east Europe, title to be announced

1500: Rossitsa Chobanova (Bulgarian Academy of Sciences, Sofia) & Nick von Tunzelmann (SPRU, Sussex), 'Innovation in Bulgaria under the transition economy'

1545: Attila Havas (Budapest and UNU/Intech, Maastricht), 'Conflicting policy needs in the first decade of transition: macroeconomic and S&T policies in Hungary, 1990-2000'

1615: Andrzej Jasinski (Univ. of Warsaw), 'Public policy and technical change in Poland, 1989/99' (invited address)

MACROTEC, Brussels, 3-4 July 2002: Towards a Schumpeterian Macroeconomics?

Venue: South East England House,

Square de Meeus 35,

B-1000, Brussels

NB: Short contributions are shown in italics

*Wednesday 3 July*

14.00 Welcome and Introduction (von Tunzelmann)

14.05 WorkPackage 2:

Overview (Knell)

a) The long-term effects of the macro-economy on S&T

Macro demand vs. supply (Le Bas)

Patterns and trends in S&T (von Tunzelmann)

b) Transition and the short-term effects on S&T

R&D declines in CEECs (Knell)

S&T in Bulgaria since 1990 (Chobanova)

c) Foreign vs. domestic technology

- FDI and national systems, Spain (Fonfria/Molero)

- FDI and national systems, Poland (Kubielas)

- Cumulative causation vs. technology gaps (Alvarez/Castellacci)

d) Meso and micro level impacts

Firm-size effects, Netherlands (Dunnewijk)

Technological natality (Le Bas)

16.15 WorkPackage 3:

*Overview (Meijers)*

a) Employment, productivity and growth

*Increasing or decreasing returns? (Knell)*

*Solow paradox (Meijers/Stehrer)*

*Labour demand and labour supply models (Socha)*

b) Skills and technology

Rising skill premia, Poland (Socha/Newell)

Skills and technological change, Netherlands (Sanders)

Patterns in transition countries (Knell/Landesmann)

Trade and skills, CEECs (Knell/Stehrer)

c) Macro policy and endogenous skill biases (van Zon)

18.15 Close

*Thursday, 4 July*

09.00 WorkPackage 4:

*Overview (Liagouras)*

a) Structure and evolution of macroeconomic policy

Varieties of policy regimes, Poland (Kubielas)

Internal and external policies (Fonfria)

b) Impacts on technology

*Technology policy and the state in S&T, France (Le Bas)*

*Technology policy and the state in S&T, Greece (Liagouras)*

Technology policy and the state in S&T, Hungary (Havas)

c) Sectoral effects and contrasts

Cost structures and macroeconomic regimes, CEECs (Radosevic)

d) Mutual compatibility of macroeconomic and S&T policies

*Growth vs. stability, Hungary (Havas)*

*Tradeoffs in economic/technology policies, Poland (Kubielas)*

*Tradeoffs in economic/technology policies, Bulgaria (Chobanova)*

11.15 Workpackage 5:

*Overview (Le Bas)*

a) Lessons from accession

*Flows of capital, technology and labour (Kutlaca)*

Productivity spillovers, Spain (Alvarez/Knell)

b) Integrating the candidate countries

Spain and EU membership (Fonfria)

Greece and EU membership (Kastelli)

*Other candidate countries (von Tunzelmann/Salavisa)*

c) Contrasts in EU policy for S&T

*Framework Programmes and Structural Funds etc. (Kastelli)*

12.30 General discussion: harmonization or differentiation?

14.00 Workpackage 1:

*Overview (von Tunzelmann)*

a) Lessons for policy from theory (Llerena)

*b) Schools of thought in economic/technology issues (Havas)*

c) Macrotec's contribution to theoretical and empirical links (von Tunzelmann)

15.45 Conclusions (round table)

a) Employment, growth and technology

b) Macro policies and S&T policies in a knowledge-driven society

c) New policy approaches

Expansion or stabilization?

Supply or demand?

d) Re-articulating policy and role of the state

17.45 Formal business – preparation of the final report, publications, etc.

18.15 Close

## 3. Project Deliverables

The following table represents the original schedule of deliverables, as given in Annex I of our initial application.

**Table 6.** List of deliverables

| Month | WP1 | WP2 | WP3 | WP4 | WP5 | Overall |
|---|---|---|---|---|---|---|
| T6 | Interim report | | | | | Workshop; 6-month report |
| T12 | Final report | Panel data report | | S Europe□ Report | | Conference; 12-month report |
| T15 | | | Specific country reports | W Europe□ Report | Countries' reports | |
| T18 | | W/S Europe Report | | E Europe Report | | Workshop; 6-month report |
| T21 | | E Europe Report | | Final Report | Post-Maastricht Report | Provisional final report |
| T24 | | Final summary report | Final report | | Final Report | Conference; 12-month report; Final Summary Report |

The format of reports on individual countries or groups of countries was not adhered to as strictly as implied in the above table, because it was found more appropriate in many cases to look at policies or groups of policies rather than groups of countries. Our eventual structure therefore represented more of a matrix of activities. In view of the potentially enormous subject matter of this project, we necessarily had to limit the cells of the matrix that we studied to only a small proportion of those possible. As stated above, the large number of meetings implied in this grid were collapsed into 5 much broader meetings that were attended by all partners. Nevertheless the topics that were analysed provided extensive evidence for our primary policy conclusions.

Except for this Final summary report, all required reports (6-month, etc.) were delivered according to schedule. The completed papers are available on the MACROTEC website:

(http://www.sussex.ac.uk/spru/macrotec).

## 4. Membership of MACROTEC and associated groups

The MACROTEC project consisted of 10 partners in 9 countries. Together with their designated research leaders, they were as follows:

**Table 7.** List of participants

| Partner no. | Institution | Designated Research Leader |
|---|---|---|
| **1** | **SPRU, University of Sussex, UK** | N von Tunzelmann* |
| 2 | Université de Lyon II, France | C Le Bas |
| 3 | MERIT, Maastricht University, Neths | H Meijers |
| 4 | LIEE, NTUA, Athens, Greece | Y Caloghirou |
| 5 | WIIW, Vienna, Austria | M Landesmann |
| 6 | IECON, Budapest, Hungary | A Havas |
| 7 | UWARS, Warsaw, Poland | S Kubielas |
| 8 | IEBAS, Sofia, Bulgaria | R Chobanova |
| 9 | UCM, Madrid, Spain | A Fonfria |
| 10 | ULP, Strasbourg, France | P Llerena |

*Project co-ordinator

**Table 8.** WorkPackage leaders:

| WP no. | Leader |
|---|---|
| 1 | N von Tunzelmann |
| 2 | M Knell |
| 3 | H Meijers |
| 4 | G Liagouras |
| 5 | C Le Bas |

In line with the original Work Programme, the Steering Committee was set up as follows.

**Table 9.** Steering Committee

| Name | Position | Nominator |
|---|---|---|
| Margaret Sharp | House of Lords, UK | SPRU |
| Lars Erik Andreasen | DG Employment | MERIT |
| Paraskevas Caracostas | European Commission | NTUA |
| Jan Krzystof Frackowiak | Under-secretary of state, KBN | Warsaw |
| Garabed Minassian | Governance board, Bulgarian National Bank | IEBAS |
| Jose Molero | Director, Instituto Complutense de Estudios Internacionales | Madrid |
| Erno Szmola | Managing Director, TEMIC (Hungarian subsidiary), DaimlerChrysler | Hungary |

Although the Steering Committee did not meet as such, its members attended some of the MACROTEC meetings, and inputs were invaluable to guiding the direction of our activities, especially in relation to policy issues.

The notion of a User Panel, intended to function as an Electronic Discussion Group, was constituted at the end of the first 12 month period. The following were nominated. They included a deliberate balance between government users (national and supranational) and industry users.

**Table 10.** User Panel

| Name | Country | Post | E-mail |
|---|---|---|---|
| A Hatziparadissis | GR | Ministry of Development | asterios@mou.gr |
| F K Delagiannis | GR | Federation of Greek Industries | talanti@fgi.org.gr |
| F Larios Santos | ES | CIRSA Interactive Corp. | flarios@mi.madritel.es |
| J C Fernandez | ES | Centre for Development of Industrial Technology | |
| S Negassi | FR | Ministere de l'Industrie | syoum.negassi@industrie.gouv.fr |
| F Chretien | FR | Aventis CropScience | francois.chretien@aventis.com |
| - | BG | Ministry of Education and Science | |
| - | BG | Union of Scientists in Bulgaria | |
| T Balogh | HU | R&D Divn, Ministry of Education | tamas.balogh@om.hu |
| I Fodor | HU | Managing Director, Ericsson HU | istvan.fodor@eth.ericsson.se |
| R Amjad | CH(GB) | International Labour Office | amjad@ilo.org |
| U Hotopp | DE(GB) | The Cabinet Office, UK | |
| R Torbett | BE(GB) | Dept of Trade & Industry, UK/DG Research, EU | richard.torbett@cec.eu.int |

European Commission

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