Overall assessment and recommendations

Introduction

In the aftermath of independence, Croatia underwent a period of reconstruction and institutional transformation. It has made much progress since, moving successfully to a market-based economy that has become closely integrated into the European and global economy through international trade and cross-border flows of investment and knowledge. Over an extended period, Croatia's solid economic growth resulted in partial convergence to the average European level of income. While it still has considerable room for improvement, Croatia's accession to the European Union can be seen as the culmination of a reform effort aimed, among other things, at facilitating investment, strengthening competition and reducing bureaucracy, and implementing the *acquis communautaire*.

The financial and economic crisis that started in 2008 revealed – even more sharply than in other countries – a number of structural weaknesses and vulnerabilities in the Croatian economy that had gone unnoticed during the period of relatively robust growth. In the years since, evidence that Croatia's erstwhile growth model may not provide a sound basis for the future has been mounting and has highlighted the need to reposition the country's economic growth and development on a more sustainable path. Boosting innovation throughout the Croatian economy and society should be an important element of a strategy for sustainable growth and rising living standards. International experience demonstrates that improved innovation performance is critical for raising productivity and thus strengthening international competitiveness in various sectors of the economy. Innovation is critical for large firms, which tend to be exposed to vigorous international competition in domestic and international markets. It helps small and medium-sized enterprises (SMEs) to modernise their production processes and management practices and find profitable product niches that allow them to be competitive and expand their markets. An innovation-friendly environment and infrastructure contributes to improving a country's attractiveness for investment and fosters structural change towards higher value-added activities. Innovation in the public sector helps provide citizens with better quality services at affordable cost.

Croatia already possesses a number of the prerequisites – relatively high levels of human capital (especially in terms of secondary education attainment, while numbers of tertiary graduates are low), some strong scientific institutions and a fledgling community of innovative start-ups – for improving innovation performance and developing an innovation system that could be a pillar of economic growth and socioeconomic development. However, it does not currently have a mature innovation system built around a highly innovative business sector core. Moreover, innovation policy in the past focused on cutting-edge, research and development (R&D)-driven innovation and on instruments aimed to strengthen the commercialisation of science. The progress made towards developing and interconnecting the elements of its innovation system has not yet resulted in broad-based economic benefits.

Achieving these benefits will hinge on tangible improvements in the framework conditions for innovation, including the regulatory environment, and further improving the human resource base and skills. It will also depend on efforts in all of the major parts of Croatia's innovation system and on developing linkages between them. These efforts include: fostering innovation in the business sector by providing the infrastructure and incentives to increase the capacity to engage in innovation (which for the majority of firms will first entail the accumulation of design, engineering, marketing and information technology capabilities and in more advanced contexts R&D) primarily in-house and, to the extent possible, in co-operation with other firms and research institutions; increasing the contribution of universities and public research institutes (PRIs) to the performance of the innovation system, including through improved steering and funding mechanisms; and improving the overall governance of science, technology and innovation (STI) policy. However, these efforts will have the desired impact only if they are designed and implemented efficiently and coherently.

The accession to the European Union (EU) offers Croatia new perspectives for the country's future economic and social development. It is clear, nonetheless, that in addition to these opportunities, full integration will also create important challenges that will have to be dealt with proactively by all actors in the economy and the wider innovation system. Notably, while Croatian enterprises will get full access to European markets, they will also face stiffer competition, especially in markets and industries that have not so far been fully exposed to international competition. This is likely to affect industries ranging from agro-food to engineering-based businesses linked to public procurement. Through changes in the external trade regime, EU accession may also result in higher barriers to some traditional markets, including in the western Balkan region. Moreover, international competition is likely to become fiercer with the further rise of a range of (newly) emerging economies and the partial reorientation of Croatian trade away from South Eastern Europe and towards the more competitive EU markets.

Boosting the international competitiveness of business firms is therefore essential. It will require a more forceful, sustained effort to improve innovation performance than Croatia has yet made in order to develop a strong, business-centred, sufficiently performing innovation system. Accession to the EU will also provide Croatia with a unique window of opportunity, including access to substantial amounts of funds for science, technology and innovation, most importantly through the EU Structural Funds (SF), and full participation in European programmes for research, technology and innovation. Finally, accession requires Croatia to adopt European standards and regulations. This will profoundly change the legal and regulatory environment that shapes framework conditions for innovation and can create an opportunity to spur innovation.

However, as in other areas, the availability of new funds and frameworks does not automatically translate into a commensurate improvement in STI performance or a qualitative change in the innovation system. International experience shows that, if insufficiently prepared, countries may have difficulty absorbing the additional funds and may put them to less than optimal use. Making productive use of significant extra funds is a demanding task and calls for good preparation in terms of strategic orientation and institutions. Experience from the use of SF for innovation in other new EU member states suggests that, among others, it is important to build adequate project planning and management capabilities in advance, to adequately involve innovation policy makers and implementation agencies, put in place effective evaluation mechanisms, and stimulate competition to improve the quality of proposals for investment.

In sum, Croatia will need a step change in the priority given to R&D and innovation in all its forms – and the resources devoted to it – to strengthen its competitiveness and move towards more innovation-driven growth. The increase in the resources available for innovation needs to be linked to greater efficiency in the administration of public funding. This in turn requires improved governance and the development of a culture of rigorous and transparent evaluation.

The purpose of this review is to identify both major opportunities and the principal bottlenecks that prevent the actors in the Croatian innovation system from realising their potential and to help them to respond adequately to and benefit from the newly emerging opportunities. The innovation potential is partly constrained by factors outside the remit of STI policy (such as the macroeconomic environment and other framework conditions). This review, however, focuses on how STI policy can make Croatia's innovation system more efficient and thus improve the country's competitiveness and overall economic performance. Mindful of Croatia's specific national context and drawing on the rich experience and good policy practices of OECD countries, this review outlines some guiding principles and provides specific policy recommendations.

Achievements and challenges: Progress on innovation capacity building has not yet yielded the expected results

During the 1990s, the Croatian economy demonstrated a pronounced tendency towards convergence with the average EU income level, with a brief interruption in 1998-99. In the decade preceding the global financial and economic crisis, gross domestic product (GDP) per capita doubled. Income per capita, which was 50% of the EU27 average in 2000, reached 64% of the EU average in 2008 in PPP (purchasing power parities). Underpinning these achievements was increased openness to international trade and investment, the liberalisation of sectors dominated by state-owned enterprises, and a number of regulatory reforms, though it remains a matter of debate whether the transition could have been carried out in ways that would have better maintained industrial and innovation capabilities. Market liberalisation was accompanied by the establishment of independent regulatory agencies. The last decade has also seen the gradual introduction of policy initiatives in support of STI, inspired mainly by the experience of EU countries. Their positive impact is reflected in observable, if modest, improvements on some innovation indicators, including indicators of scientific output, impact and internationalisation and, to a lesser extent, patenting. However, many of the country's achievements do not appear remarkable when compared with those of other former transition economies of similar size and income per capita.

The global financial and economic crisis brought the process of convergence to an abrupt end. After a sharp drop in GDP of nearly 7%, Croatia's economy has not returned to sustained growth, and was in recession again in 2012. Unemployment has reached high levels. Given the current macroeconomic environment, prospects remain subdued. Even if the period between 2000 and 2008 is included, growth has been slower than what might have been expected, and below that of other emerging European economies. Recent developments have cast doubt on whether the previous growth model, which was credit-fuelled to a significant extent, will enable Croatia to achieve high sustainable growth in the future. There is evidence that its GDP growth was mainly driven by capital accumulation. It was much less due to growth of total factor productivity (TFP), which indicates increases in the efficiency of production. Labour productivity growth has also been rather low by international standards, even before the crisis.

Stronger innovation performance will be an important part of a Croatian strategy for a transition to a trajectory of high, sustainable growth and better living standards for its population. It is fair to say that Croatia does not currently have a mature innovation system, although some elements of such a system and pockets of excellence are in place or emerging. Its innovation system remains small in both absolute and relative terms. Gross expenditure for R&D (GERD) has been stagnating, and this funding shortfall has affected the employment of researchers. Both public and private R&D budgets were particularly affected by the crisis; in fact, Croatia was one of the least resilient countries in Europe in this respect. Moreover, in a longer-term perspective, aggregate research intensity – the ratio of GERD to GDP – declined over the last decade. The magnitude of this decline is exceptional by international standards and contrasts strongly with progress made by many countries, including emerging economies. The decline in R&D intensity is also suggestive of an absence of structural change towards knowledge-intensive sectors that would create employment opportunities for the highly skilled.

While the propensity of companies in Croatia to engage in innovation seems broadly in line with countries of similar income per capita, innovation outcomes appear low compared to other countries and in relation to the resources devoted to innovation. Technological and scientific output has relatively low impact as measured by patent and article citations. The above-average productivity of Croatian scientists and their relative cost effectiveness are the positive exceptions in a system that is operating considerably below potential.

Given the rather small contribution of TFP to economic growth, the Croatian economy has not yet benefited significantly from its incipient national innovation system, which is characterised as much by pronounced resource constraints and considerable volatility as by a weak governance record and suboptimal funding arrangements, accompanied by unsystematic monitoring and evaluation. It is therefore not enough simply to address resource constraints, although a steady allocation of sufficient funding would be necessary to enhance the innovation system.

Main strengths and weaknesses of the Croatian innovation system

History and geography have given Croatia certain strengths and conditioned its development trajectory. Overall, and until relatively recently, the institutional framework did not facilitate market-oriented innovation. Capabilities in the business sector have tended to decline over time and the country's current industrial strengths are mostly those of the twentieth century. The country's geography and the prospects opened by joining the EU, while they offer many opportunities, may also carry risks, some of which appear not to have been fully appreciated and adequately dealt with in advance.

Main strengths

- *Croatia has a well-educated population, especially in terms of secondary education.* The share of the adult population having completed upper secondary education is above the EU27 average. The country has a tradition of learning and scholarship, with pronounced strengths in the sciences, law and the humanities. It possesses a diverse portfolio of higher education institutions catering to a large array of regional and sectoral education niches. Both universities (the University of Zagreb features in global rankings of leading universities) and PRIs (notably the Rudjer Boskovic Institute) have pockets of research excellence. Recent years have also seen an increase in scientific publications and an improvement in the

impact of scientific output. There are indications that Croatian scientists are more productive than scientists in many comparable countries and are relatively cost-efficient.

- *Croatian firms possess export strengths in a range of industries and there is also a small number of relatively strong R&D performers.* Relatively strong R&D performance, notably in pharmaceuticals and electrical and electronic equipment, including information and communication technology (ICT), has attracted the interest of multinational enterprises and led to restructuring in the wake of mergers and acquisitions. "Greenfield investment", instead, has been largely absent, thereby limiting a potentially important source of industrial renewal. Even the "large" R&D performers are small by international standards.
- *A community of innovation-oriented start-ups and established enterprises can be found among the country's SMEs*, sometimes in specialised niches where they have developed significant competences and some export strengths, especially to south-eastern Europe.
- *A privileged geographic location* on the Adriatic coast and at the crossroads of central and south-eastern Europe, as well as historical links with several OECD and emerging economies. These advantages have contributed to inward foreign direct investment (FDI), a small part of which is in knowledge-intensive or R&D-performing sectors. Overall, these inflows have been smaller than in comparable countries. Joining the EU will further open the Croatian economy to international trade and investment and will create opportunities for increased international knowledge flows which should be seized. Croatia will also participate in EU programmes for research, development and innovation on an equal footing.

Main weaknesses

- *Weak macroeconomic performance in the wake of the financial and economic crisis.* The crisis laid bare structural weaknesses that had gone unnoticed. Croatia's gap in per capita income is partly due to lagging labour productivity *vis-à-vis* the European or OECD averages. This suggests the need to focus on enhancing productivity, most importantly through broad-based improvement in the innovation performance of Croatian companies.
- *Inadequate framework conditions for innovation owing to an incomplete reform process.* There is still much room for improvement in the regulation of product markets, investment (facilitation of firm entry and exit), and labour markets (labour force participation and turnover). Despite progress, bureaucratic red tape remains burdensome, with delays and difficulties in obtaining licences and in contracting utilities, and there is considerable ground to cover to adopt and implement EU regulations. Corruption continues to be an important barrier to innovation.
- *Weak innovation capabilities in the business sector.* Business R&D expenditures are exceptionally low by international standards, even after accounting for differences in industrial structure. Inputs to innovation and the associated human resources and physical infrastructure lag comparable countries. Low levels of innovation and research activity translate into weak in-house capabilities and absorptive capacity, an important obstacle to collaboration with universities and other knowledge providers. Yet, Croatia has some dynamic SMEs that benefit

from R&D and from non-R&D-driven forms of innovation such as organisational and marketing innovation. Businesses in some knowledge-intensive industries depend on public procurement and are likely to face more vigorous competition in the future. Relative export unit values – the value of exports per unit of quantity, which, under certain conditions can be interpreted as an indicator of product quality – suggest that the competitiveness of Croatian exports continues to be based on cost rather than quality, which is associated with investments in human capital and innovation.

- *A skills profile that is unfavourable to innovation in the business sector*. Business innovation capability depends crucially on specialised skills in design, engineering, marketing and information technology, among others, and on the innovation demands and activities that the presence of such skills generates in firms. International evidence suggests that it is largely firms themselves that create such capabilities in the course of their activities. Yet, businesses based in Croatia lag internationally, even compared to other countries in the region, in terms of investment and participation in formal firm training. Moreover, Croatia lags comparable countries in terms of the share of employment accounted for by knowledge-intensive sectors, the rate of employment of tertiary-educated and their share in total employment, as well as the employment of ICT specialists. Evidence from the latest Community Innovation Survey (2008-10) and a more recent OECD survey (conducted in 2012) suggests that lack of qualified personnel is a significant barrier to innovation in Croatian companies. The education system does not appear to address this weakness, and Croatia lags comparable countries in terms of participation in adult education. Past studies have also highlighted mismatches between industry demand and education system supply. The mismatches include entrepreneurship skills as well as a range of science, engineering and mathematics disciplines, given the bias towards the social sciences and the humanities among Croatian tertiary education graduates. There are some indications that the share of professionally oriented tertiary graduates and of secondary-level vocational graduates may be insufficient. Internationally comparable student assessments of the quality of science and mathematics education place Croatia below similar countries and the EU average. This can be a cause for particular concern as cross-country evidence suggests that the quality of science and mathematics education is a predictor of long-run technological dynamism.

- *Weaknesses in the organisation and governance of universities and PRIs*. Current university management structures, in which each faculty is a separate legal entity, make institution-wide strategic planning almost impossible and potentially hinder even routine activities such as monitoring and evaluation. Croatian universities and PRIs are difficult to steer, as the "locus of control" is not the top management but committees composed of second-level managers and representatives of academic staff. This mode of governance or management tends to support reciprocal behaviour and structural dependencies and thus to prohibit the adaptations in internal organisation, priorities and incentives that are required to build strong, high-performing universities. Past attempts by the Croatian government to reform the higher education sector have met with strong resistance and were abandoned. PRIs are also fragmented but in a different way; the fragmentation is between rather than within organisations. This fragmentation may have prevented large-scale, long-term projects and is confirmed by the low level of capital investment and the modest expansion of the last decade.

- *Failure to adapt international policy practices sufficiently to national settings*. In the last two decades, Croatia has set up many programmes and instruments to foster STI. Their choice and design were often influenced by developments in advanced innovation systems. The past decade has been characterised by a predominance of instruments to transfer technology between academia and industry, including through technology parks and incubators, public-private partnerships, etc. While this has been useful in particular contexts, an excessive orientation towards R&D-intensive modes of innovation and technology transfer may not fit the primary needs of an emerging innovation system such as Croatia's, notably if it is not accompanied by systematic support for broad accumulation of innovation capacity, especially in the business sector.
- *An inadequate division of labour between the government and the agency level*. While government ministries have delegated a number of programmes and measures to institutions such as the Croatian Business Innovation Agency (BICRO) and the Croatian Science Foundation (CSF), they have kept others within their own organisation and responsibility. This arrangement has been unsatisfactory from various perspectives: separation prohibits pooling and the creation of critical mass in terms of stability, managerial capacity and intelligence at both the policy and agency levels. It also hinders economies of scale and scope. In addition, the smaller the number of programmes and measures, the lower the readiness to change the portfolio, as the various parts of the administration tend to protect "their" programmes.
- *A lack of trust* has pervasive consequences as it prevents inventors from seeking the needed investment for commercialisation, central government from delegating responsibilities, university-industry collaboration and investment in innovation, and may influence the government's choice and design of support instruments. The problem is compounded by a lack of transparency in public dealings, weak monitoring and evaluation of government-financed schemes, and lack of feedback once schemes have been completed. Confidence in the system will inevitably be a reflection of its long-term success, but greater transparency, better monitoring and evaluation, and community-building schemes that cut across ministerial/departmental and institutional boundaries would be steps in the right direction.
- *A lack of sustained political commitment to matters of innovation*, finally, is one of the most important constraints. Practically all of the important "success stories" about countries catching up to become major players in innovation (from Korea to Finland) were backed by strong, sustained political commitment. The lack of high-level political commitment is at the root of several problems for the Croatian innovation system: the proliferation of plans and policies without adequate endowment, councils that are not operational, the lack of policy continuity and strategic outlook, the limited resources devoted to R&D and innovation in general, the extraordinary vulnerability of STI budgets, the success of special interests in resisting change, inefficient governance arrangements, and the difficulty of co-ordinating policy and implementing needed complementary changes in other parts of the innovation system. This contributes to a "credibility gap" between the promise of innovation for economic growth and development (based on theory and international experience) and what many in the country believe can be achieved in Croatia. The problem is probably not unrelated to the general lack of trust mentioned above.

Opportunities and threats

- *The use of EU Structural Funds and greater use of national funds* provide an unprecedented opportunity to upgrade innovation capabilities across the Croatian innovation system. In the absence of the positive feedback processes characteristic of successful innovation systems, a sustained initial stimulus is usually required to kick-start a virtuous circle. The absorption of EU Structural Funds (SF) and further mobilisation of Framework Programme (FP) funds could help provide that stimulus but would generally aim at capacity building (SF) and precompetitive R&D (FP). National public funds, especially when they leverage private R&D investment, may complement the European funding "push" e.g. in providing support for near-to-market innovation and commercialisation. Such support should be strategic and conditional on strict criteria of quality.
- *Nurturing the development of a dynamic business sector that thrives on innovation.* Full access to EU markets presents opportunities for expanding exports, including in high value-added sectors, if the business sector develops the innovation capabilities to sustain a path of productivity, quality improvement and thus international competitiveness. Government policy can help by supporting better utilisation of Croatia's labour pool and comprehensive upgrading of skills that are relevant to industry. Improvements in framework conditions for innovation and in the institutional and material infrastructure that will support a dynamic innovation system can also contribute. Nurturing innovative, export-oriented firms may also require initiatives to lower costs of entry to and transactions in international markets, as well as a supporting regulatory environment and information and logistical infrastructure.
- *Increasing the contribution of public research to social and economic development*. Croatia's public research – both universities and PRIs – has the potential to contribute more to the country's socioeconomic development. The binding constraints are not simply the volume of funding but also the organisational, governance and management practices, incentives and perceptions that prevail in the public research sector, which are in many respects not well suited to this effort. A shift towards performance-related governance and results-based management models may facilitate a paradigm shift. EU Structural Funds could contribute significantly to the implementation of such models owing both to the substantial amount of funding and to fact that their rather long duration provides a stable environment for (institutional) learning.
- *Use of sectoral policies to foster innovation in the relevant sectors (such as energy, transport and agriculture)*. Clusters and mission-oriented PRIs typically have a strong sectoral orientation. At the same time Croatia has been establishing and strengthening specialised agencies (in areas such as water, energy, environment and food) in charge of supervising and implementing regulations. Collaboration by the different actors can provide substantial leverage for performing research and for designing and launching related support services, training and consulting.

At the same time, the Croatian innovation system faces a number of *threats*:

- Volatility of the international macroeconomic environment, including in Croatia's European neighbourhood.

- *Failure to prepare for increased competition following EU accession.* Fiercer international competition may threaten the viability of previously sheltered or less exposed industries. Croatian firms participating in the Central European Free Trade Agreement (CEFTA) area may have difficulty shifting from regional markets to the EU market. In particular, reinforced specialisation in sectors with adverse terms of trade over the long term and limited opportunities for innovation and productivity improvements must be avoided.
- *Failure to generate a tangible economic impact from increased investment in STI.* In the absence of adequate institutional reform and preparation, a sudden increase in resources devoted to innovation (primarily from EU Structural Funds, but also from other sources) may not be accompanied by a proportionate increase in outputs or meaningful impacts on the Croatian economy.
- *Increasing bias towards rent-seeking activities*. Large amounts of Structural Funds may reinforce tendencies towards redistributive "rent-seeking" entrepreneurship, objective of which is to maximise the appropriation of the funding windfall rather than the accumulation of productive and innovative capabilities. The risk would be heightened by a lack of economic dynamism and by difficulties in identifying profitable opportunities for investment.

Scope for improving innovation policy

In Croatia, market-oriented innovation policy is a relatively recent undertaking. Some key actors, supporting processes and institutions have had to be created. Specialised government institutions or agencies, such as the Croatian Business Innovation Agency (BICRO), the Croatian Science Foundation (CSF) and the Agency for Science and Higher Education (ASHE), address important innovation system functions, from implementation and delivery of public research programmes and support for business innovation to evaluation of research and quality assurance. These intermediary organisations have already experimented with a variety of support instruments and amassed considerable context-specific experience. The institutional framework for innovation has potentially been strengthened by the establishment of the Agency for Vocational Education and Training and Adult Education and the Agency for Mobility and EU Programmes, as well as by efforts to upgrade the role of the State Intellectual Property Office.

While substantial progress has been made in overall policy capacity building, particularly through the set-up of specialised agencies, there remains considerable room for improvement in the orientation, planning, implementation as well as in the monitoring and evaluation of innovation policy.

- *Policy orientation.* The overall orientation of innovation policy should be in line with the current stage of development and the specific challenges it poses. Non-R&D-driven forms of innovation, including services and marketing innovation, may be more relevant in an emerging innovation system. This will change over time as capacities are accumulated. Priority setting needs to become a routine practice. Striking an appropriate balance between pragmatism and ambition, and allowing this balance to evolve over time, will be crucial. Cross-sectoral co-ordination will be of utmost importance and will require co-ordination of and balance among stakeholders.

- *Planning, implementation, policy advice.* Improved planning is only possible when policy is informed by past experience and performance. This implies that actors (agencies) specialised in policy implementation need to have sufficient opportunity to accumulate the necessary experience. In this context, the continuity, scope and operational independence of intermediary organisations such as BICRO, CSF or ASHE are crucial to a successful Croatian innovation policy. This implies abandoning some past practices. While various new agencies and councils have been established in recent years, functional specialisation and range of action have remained limited. New policies, plans and strategies often lack sufficient resources to implement them. In some cases, the creation of auxiliary organisations (such as incubators, etc.) has not been accompanied by reform of the institutions they serve, notably higher education institutions (HEIs) and PRIs.
- *Steering in the public research system*. The main obstacles to the adoption and implementation by HEIs and PRIs of broader, longer-term strategies relate to: the presence of separate funding streams based on different rationales for salaries, consumables and investment, which results in a lack of budget flexibility; within HEIs, a largely fragmented governance system with a high degree of decentralisation and autonomy; in PRIs, a mode of governance that leads to suboptimal interaction with relevant environments, including the scientific and business communities. At the level of institutions, governance should foster a better alignment of national and institutional planning.
- *Funding of public research*. Overall, funding of public research and public support for innovation in the business sector seem too low to have a meaningful impact. Future funding policy needs to address the following challenges:
  - *Establishing strong and explicit relationships between project funding and institutional funding in the HEI and PRI sectors, supported by performance contracts*. PRIs' performance contracts should explicitly relate institutional funding to income from project-based funding (grants) and to income from research contracts and related services. This also applies to HEIs, taking due account of their educational functions. The main challenge is to reward both past performance and a coherent strategic vision for the future.
  - *Establishing strong and explicit relationships between SF funding and funding from national sources*. Linking SF funding and funding from national sources has a potentially high impact as it combines the funding with changes in major parts of the performing sector and the governance system. It will require new structures in the HEI and PRI system that link critical elements and support interaction. A major focus should be skills provision, including training young researchers in close relationship with the business sector. Another important focus is the funding of (regional) development agencies that provide hands-on services, with a focus on SMEs ("clusters"). Still another is institutional learning, including by agencies, as they implement the various programmes.
- *Monitoring and evaluation*. Formal monitoring arrangements are underdeveloped, feedback is poor, and evaluation at the level of programmes and support measures is not standard practice. The SF programmes and related projects will give an opportunity to establish a rigorous evaluation culture. This will enable learning as

a result of the accumulation and use of own capacities and of engagement with domestic and foreign experts that feed back into decision making. Another notable direction is linking effective *ex ante* evaluations to the negotiation of performance contracts. For instance, the Czech Republic used a combination of *ex ante* evaluation and negotiation of performance contracts to save EUR 200 million out of EUR 1.6 billion, which was then used to fund additional projects. Overall, the preparation and implementation of SF programmes and projects calls for the development of a range of policy intelligence functions (orientation, planning, monitoring, evaluation) that should be a starting point for developing and implementing a more advanced overall evaluation system.

Strategic tasks and guiding principles

The development of the Croatian innovation system is still at a relatively early stage. The role of innovation policy will vary as the system evolves. Innovation policy should therefore set its sights on goals that are both relevant to current stage of development and adequately anticipate the next.

The key strategic policy tasks will be to:

- *Strengthen political commitment, responsibility, continuity and co-ordination.* Political commitment is a fundamental precondition for meaningful innovation policy co-ordination. Over the past ten years, political commitment has been insufficient in terms both of budget share and reliability. Decisive steps will have to be taken to stabilise public funding for innovation and ensure continuity beyond the budgetary and electoral cycle. A clearer division of labour between the central government and independent agencies, coupled with stronger governance arrangements for inter-ministerial and inter-agency co-ordination, preferably with the involvement of the highest political level, will be central to successful implementation.

  Facilitate mobilisation of resources and the build-up of innovation capabilities in the business sector. Increasing the resources for innovation should be a primary aim of innovation policy. In particular, strengthening innovation capabilities in the business sector should be a priority. There is great potential for using EU instruments (SF, FP) to leverage business funding of innovation. At the same time, realistic goals should be set, as progress will take time. The policy approach should be in line with the business sector's current needs rather than directly transferred from advanced innovation systems. Inevitably, this will require a variety of more direct and better-funded support measures. The build-up of business innovation capabilities will also require policy initiatives that go beyond innovation policy, including strategic planning in industrial and education policy.

- *Enhance the contribution of universities and PRIs by ensuring effective governance.* Improvements in the governance, evaluation and accountability of organisations, individual research performers and policy instruments should go hand in hand with increasing resources. Performance-based budgeting has proved to be an effective approach.

Guiding principles

- *Leadership and commitment to leading to stability and predictability of framework conditions and resources.* This ensures that innovation actors in the business and the public research sectors are in a position to plan investments adequately. International experience demonstrates that this is essential for the success of innovation policy.
- *Effective governance arrangements and feedback.* Focus on effective strategic and operational functions, using evaluation and feedback mechanisms to inform successive rounds of decision making, based on a strong evidence base.
- *Effective co-ordination*. Improvements in framework conditions for innovation as well as dedicated policy measures for STI often cut across policy areas and require (horizontal and vertical) co-ordination. Co-ordination requires effective communication across organisations and institutional sectors as well as effective monitoring and evaluation of contributions. Broad stakeholder involvement in policy decisions and more interaction within the policy-making community will be needed.
- *A broad concept of innovation,* including non-R&D-driven types of innovation. This both allows and requires tighter, more systematic collaboration between generic innovation policy and sectoral policies, on the one hand, and use of regulation as a vehicle for innovation, on the other.
- *Setting the bar at the international level.* Placing the innovation system in an international perspective (e.g. through international peer review and the HEIs and firms' export ambitions) could lead to improved performance in the innovation system in terms of efficiency, quality and economic impact. Increased international openness and orientation can encourage competitiveness in firms and excellence in scientific research.
- *Performance orientation*. In order to raise the performance of the Croatian innovation system it is necessary to relate funding to long-term goals, targeted actors and related achievements. This includes the implementation of performance-based budgeting in HEIs and PRIs and contractual relationships between the government and its agencies, on the one hand, and a high degree of managerial autonomy, on the other hand.
- *Ambition, prioritisation and realism.* The country's ambitions should be tempered by a realistic assessment of existing capabilities and requirements for implementing change, including the time horizons involved. It is often difficult to change quickly, and the most important changes must be a priority. A long-term strategic outlook that evolves progressively but remains mindful of the system's current challenges will need to be adopted.

Recommendations

Improving framework conditions for innovation

Croatia enjoyed a stable macroeconomic environment during the years preceding the global financial and economic crisis, with solid growth, contained inflation and stable exchange rates. Economic growth was achieved in the face of adverse demographic trends, relatively high unemployment and low labour force participation. The crisis and

its aftermath had a negative impact on an already unfavourable trade balance and public finances have come under stress. Moderate gains in labour productivity were mostly due to capital deepening; the contribution of overall efficiency in the use of factors of production was minimal.

While Croatia is a relatively open economy, with trade and FDI increasing over the last decade, these remain below the levels of comparable economies. The competitive pressures faced by companies across sectors, which can provide a powerful incentive to innovate, are uneven. Although there is evidence that the degree of industrial concentration has decreased over the past decade, pockets of high concentration persist, especially in sectors in which the government had or maintains important stakes. Concentration has increased in some industries that have attracted the entry of multinational enterprises (such as computers and related services, manufacture of tobacco products and retail). The establishment of the Croatian Competition Agency and its recent extension of powers represent important steps in securing and maintaining a level field.

Businesses' access to finance for innovation is mixed. While a variety of arrangements meet a relatively wide array of needs, many smaller companies still find it hard to secure funding owing to strict technical regulations and the need for collateral. As in other countries, there is little capital available for risky investments. Overall, while the legal and regulatory environment has improved somewhat in recent years, important constraints remain, including a still burdensome bureaucracy and a less favourable tax regime than in the average OECD country. A lack of trust is an important issue, including in the effectiveness of legal institutions.

- *Establish and maintain a favourable macroeconomic environment* and fiscal sustainability, while fostering investment in science, technology and innovation.
- *Continue the process of reform*, shifting emphasis from the nominal requirements of compliance with the *acquis communautaire* to the measureable impact of regulatory changes in facilitating investment and the functioning of markets. The prevailing macroeconomic environment and the need to improve competitiveness call for continued reform even after accession to the EU.
- *Link the adoption of EU regulations with corresponding support measures* to facilitate their timely and effective adoption by the business sector and to trigger the adoption of a stream of associated or complementary organisational and process innovations. Such measures will require closer co-operation between relevant ministries and BICRO.
- *Identify and address any aspects of the framework conditions that reduce the attractiveness of R&D and innovation investments in Croatia,* including the administrative burden faced by companies, obstacles to SMEs' access to finance, and facilitate the funding of risky investments. In this respect, it may be useful to introduce an innovation dimension in the criteria of ex ante and ex post regulatory impact assessment.
- *Foster public-sector innovation, including through greater use of ICT in the delivery of public services,* with the set-up and modernisation of information platforms for STI policy, as well as process and organisational innovations.
- *Place emphasis in public-sector reform on transparency and on reducing the incidence, potential and perception of corruption.* Although Croatia has made

notable efforts recently, there are indications that corruption is an important constraint for smaller businesses.

- *Strengthen competition and ensure that a level playing field is maintained over time, thereby putting in place strong incentives to innovate.*

Strengthening the human resource base for innovation

The Croatian workforce is relatively well qualified but its skills profile may limit its innovation potential. Compared to the EU and countries with similar income per capita, Croatia has few students and graduates in mathematics, science and engineering, low share of tertiary educated workforce, low rate of employment among tertiary graduates and one of the lowest levels of on-the-job training and lifelong learning. Croatian companies report a lack of qualified personnel in the workforce as an important constraint on innovation. Lack of qualification often refers not only to formally acquired competences but also to past experience with innovation and its economic appropriation. A community of consultants or associated services to support businesses in innovation projects is not widely available.

Croatia is above the EU average in terms of the share of young population receiving secondary education. However, Croatian secondary students score behind comparable countries in mathematics and science in the OECD's PISA surveys, indicators which correlate with technological innovation performance across countries. Education in universities is insufficiently aligned with the needs of the labour market. This is evident in the structure of graduates by discipline (particularly the strong weight of the social sciences), and the fact that industry and local community organisations do not appear to be involved in curriculum setting.

Businesses often report a lack of so-called "soft" skills in management, marketing, entrepreneurship and intellectual property law. Traditional strengths in social sciences, law and humanities could be drawn on if the social relevance of education, training and research in universities and PRIs is reinforced. They could be mobilised to facilitate innovation in service and marketing innovation and to support sectoral innovation strategies, including in tourism. In addition, existing capacities in the social sciences, law and humanities could facilitate the training of human resources to improve companies' capacity to appropriate knowledge.

Multinational enterprises (MNEs) value locally trained researchers and appear willing to extend privately funded PhD opportunities. However, industry-oriented PhDs are not very popular with students, and industrial relevance is sometimes seen as a distraction from formal evaluation credentials, such as scientific publications. Changes may be needed in the academic incentive structure, with a detailed examination of non-academic career paths for researchers.

There are also indications of bottlenecks in the transfer of knowledge from abroad, as suggested by the low levels of inward and outward mobility of researchers and the low incidence of international co-publication relative to comparable countries.

Policy attention is also warranted to identify present and future skills needs of relevance to innovation in general and to the innovation capacities of the business sector in particular and to manage study programmes accordingly. The focus over the past decade on researchers, the scientific diaspora and other cutting-edge skills – important as these are – would need to be complemented by attention to a wider range of specialised, occupation-oriented skills. This should first be the subject of a comprehensive study;

next, formal mechanisms should be established to identify skills needs and to strengthen and expand the alignment of skills supply.

Available evidence point to the need to strengthen (non-academic) professional education at the tertiary and master's levels, areas that seem especially weak relative to comparable countries and are important for strengthening innovation capabilities in general and in the business sector in particular. The stronger presence of private education providers in the supply of this education in polytechnics constitutes a strong signal that there is a gap.

An important aspect of this effort will be the transfer of expertise, possibly by pairing with leading tertiary vocational education providers from abroad (e.g. Germany, United States, Ireland) in developing and delivering professional undergraduate programmes and academic master's programmes. Ireland's experience with using SF to develop its highly successful and respected institutes of technology may be a useful guide. In addition to improving the quality of vocational and master's programmes, an association with globally prestigious providers may help improve the attractiveness of vocational education to prospective students.

- *Encourage the study of science and technology* by stimulating interest in and take-up of relevant courses and offering places in the education system, along with measures to improve the attractiveness of associated career paths. Specifically, more consideration should be given to the training needs of researchers for the business sector.
- To eliminate skills mismatches based on systematic skill gap analyses, *put in place mechanisms to encourage interaction between industry and academia on decisions regarding curricula and assessment in higher education*.
- *Provide additional avenues for upgrading the skills of those already in the workforce and increase opportunities for and awareness of lifelong learning.*
- *Facilitate entrepreneurship through the development of relevant skills.* Mobilise existing capacities in the social sciences, law and humanities to improve companies' capacity to appropriate knowledge.

Improving the governance of the innovation system

Overall governance

Governance of innovation policy in Croatia is characterised by an absence of co-ordination, piecemeal programming and lack of continuity over time. The want of sustained political commitment has translated into haphazard strategic orientation and planning, shortfalls in implementation, and, sometimes, from the viewpoint of stakeholders, insufficiently credible policy initiatives. Long-term strategic orientation and programming are hampered by the volatility of R&D budgets; in recent years, these have been on a biennial cycle of double-digit growth, followed by sharp contractions of the same magnitude. Instability of this kind has negative impacts on human resources, investment and long-term research activity. Similarly, policy measures are not adequately prioritised and endowed with resources and do not achieve their full potential in terms of impact. International experience shows that much can be gained if top-level government focuses on providing an overall orientation and uses public resources to facilitate and leverage private investment in innovation in areas of strategic importance. Resource mobilisation will also hinge on changing perceptions: giving greater visibility to past

successes and emphasising their tangible economic benefits may help capture imaginations and strengthen political commitment to a long-term innovation strategy.

The public administration is currently characterised by strong compartmentalisation and uneven performance. While there has been some experience with programme design and experimentation with alternative instruments, programming remains piecemeal and is not yet part of a long-term strategy. Particular problems arise from incomplete "agencification" (some programmes and measures are managed by agencies, others by the ministries), an imbalance in policies, strategies and plans and their resources, ineffective governance of the largely fragmented HEI and PRI sectors, and rather weakly developed policy intelligence (monitoring, evaluation) in terms of reach and quality. However, there are clear signs of improvement in the gradual delegation of management of programmes to agencies and the example of ASHE, which appears to meet European standards and act as an anchor in the higher education system.

Responsibility for STI policy is shared by three ministries: the Ministry of Science, Education and Sports (MSES), the Ministry of Economy (MoE) and the Ministry of Entrepreneurship and Crafts (MoEC). MSES is the most prominent government body in STI matters; it is primarily responsible for programming, co-ordinating and monitoring science and education policies and has an important role in shaping innovation policy. For innovation policy in particular MSES shares its remit with MoE and MoEC. In anticipation of EU accession, the Ministry of Regional Development and EU Funds (MRDEUF) was established to integrate and co-ordinate the numerous EU policies and funding schemes.

The existing division of labour between the government level (in particular MSES, MoE and MoEC) and the agency level (in particular BICRO, HAMAG-INVEST and CSF) could be improved. While the central government has delegated a number of programmes and measures to operationally independent agencies, it keeps others in ministries. This halfway arrangement prohibits the creation of critical mass in terms of managerial capacity and intelligence at the agency level; with respect to the responsiveness of the policy mix, it lessens readiness to change, as people (and institutions) tend to protect "their" programmes and measures. Agencification should be accomplished by establishing meaningful and stable agency functions with the necessary operational independence and governance mechanisms. Pooling programme delivery creates better opportunities for building a larger portfolio of instruments and developing an internal specialisation and labour market.

The upcoming programming of the SF will create opportunities for introducing long-term strategies in a number of sectors. A challenge beyond the long-term orientation of the SF programmes will be tight linkage to relevant sectoral policies. Sectoral agencies (food, energy, etc.) can act as strategic partners for access to these sectors and become partners in achieving innovation policy goals.

As shown, Croatia possesses institutional actors and a record in innovation policy that can be built upon and developed to be ready for the next steps. Political commitment, leadership, realistic implementation plans, pursued vigorously and consistently over time, will be necessary.

- *Consider permanently raising innovation policy to the highest level of government*. This has been achieved in different ways in other countries, including the creation of a dedicated ministerial portfolio, the attribution of responsibility to the office of the prime minister, or the establishment of a top-level council, sometimes chaired

by the prime minister. Whatever the arrangement, it will deliver the desired results only if it is backed by strong commitment in practice.

- *Give high priority to the steady flow of sufficient funding for R&D and innovation*. This is a precondition of credibility, trust, long-term planning, and above all for a profound reform of the HEI and PRI sectors. EU membership and the new Structural Funds programming period (2014-20 plus two years extension) will create an historic opportunity that must not be missed. As there are many potential pitfalls, agenda setting, planning, institutional set-up and operational implementation are very important.
- *Establish a clearer division of responsibilities and consolidate overlapping competences of relevant ministries and the relevant, operationally independent agencies (such as BICRO and CSF)*. As a general principle, ministries should concentrate on policy making and strategic orientation and delegate execution to operationally independent agencies. The agencies should have strong and explicit relationships with the ministries, a reliable system of supervision, and operate in a situation that allows for systematic learning and improvement. Membership in international environments for learning and quality control is important. ASHE may act as a role model in a number of regards. BICRO and CSF should be extended and empowered to act as the single Croatian innovation agency and scientific research council, respectively. Adequate governance and management mechanisms must be implemented. Membership in professional organisations (TAFTIE, Science Europe) and regular external evaluations will contribute to quality assurance.
- *Give high priority to linking national support programmes with Structural Funds*. As SF allow for a high degree of flexibility while providing a stable, longer-term framework, they can be used to accomplish tasks that are critical fo*r the further development of the innovation system.* These include initiating and supporting the reform of the HEI and PRI sectors to strengthen both, and establishing a system of instruments and measures that support a broad concept of innovation (e.g. non-R&D-based innovation, innovation in services, implementation of standards and regulations as a vehicle for innovation, networking, consulting etc.). This would strengthen the tendency towards international evaluation, global relevance and international collaboration and can enhance the quality and international impact of knowledge output.

Policy mix and specific instruments

During the last decade Croatia has adopted and implemented a broad range of innovation policy instruments. For the business sector, the main instruments are clustered around BICRO and are strongly oriented towards support for technology-based start-ups, transfer centres, incubators and R&D centres, contract research with HEIs and PRIs, support for the proof-of-concept phase and for participation in EUREKA. While these instruments remain in place, consultancy for high-technology SMEs and subsidies for pre-commercial R&D have been terminated; provision of venture capital has never started. Overall, BICRO's activity is still strongly shaped by the concepts prevailing at the time of its establishment: research-based innovation, taking advantage of public-sector research, a preference for high-technology SMEs, etc. BICRO has not broadened its instruments to address challenges such as firms' absorptive capacities and a broader notion of innovation. Business support by BICRO seems to have resulted in a number of

successes (firm and employment creation, leveraging of private co-funding) despite tight resource constraints. HAMAG-INVEST is another agency that targets the business sector. It mainly provides general financial support and, more recently, consultancy services for SMEs. In recent years it increasingly uses regional development agencies or business centres as hubs for delivering its services. Innovation has been, at best, an implicit issue on HAMAG-INVEST's agenda; however, this is bound to change as a result of its forthcoming merger with BICRO. There do not seem to be any systematic attempts to co-ordinate the work of specialised agencies (energy, environment, food, etc.) with innovation policies or between these agencies and specialised PRIs, which could potentially create synergies between sectoral policies and general innovation policy.

The current tax incentives for R&D seem mostly to benefit medium-sized to larger firms, providing support for maintaining or increasing their R&D investment in Croatia. They provide much less support for smaller, less R&D-oriented firms and innovation more broadly. There may be a need to review tax incentives with a view to their opportunity cost and other potential impacts.

CSF manages a cluster of instruments addressing the higher education and the public research sectors. These instruments mainly tackle issues concerning HEIs and PRIs through grants (for research projects, training of doctoral students, brain gain, reform of higher education management, or internationalisation, including access to international research infrastructures). The number of funding schemes was reduced when CSF took over the research grant schemes from MSES.

The main issue regarding the policy mix and policy co-ordination is less one of fine-tuning of individual programmes and instruments and their co-ordination than of poor endowment. The overall funding provided to BICRO and even the funding managed through other schemes and tax incentives are exceptionally low by international standards. CSF has been far from having the resources necessary to have a profound impact on the scientific research community.

In the overall innovation policy mix, there has been a notable focus on technology transfer, incubators and academia-industry collaboration. This focus, including the implementation of various funding instruments and programmes, reflects in some respects the dominant international policy debate. The "binding constraint" in Croatia may well be a lack of actors with sufficient R&D and innovation capacities and institutional incentives to accumulate capacities (or to be rewarded with additional resources), rather than a lack of linkages or interaction between academia and business *per se* (desirable as they are). This would suggest the need to rebalance the policy mix to include instruments for overall capacity building, to bring about institutional reform that align incentives to this goal and reward performance and interventions aimed at increasing business capabilities and demand for innovation (and related services). Specifically, this would mean developing and enriching the range of funding and other support services that address innovation in the broad sense through capacity building, productivity enhancement, incremental innovation and upgrading. On the agency side, this requires an agency function that combines a portfolio of funding instruments with non-monetary support services such as consulting, coaching, information brokerage, and linking up with other policies. Competence building and stability and continuity in the agencies and their staff are key requirements for a long-term impact from funding.

- *Emphasise increasing the absorptive capacity of business enterprises, a major prerequisite for any kind of innovation.* Systematically link innovation policy measures with education and training (in particular vocational training and continuous learning) and with measures to foster the employment of highly skilled human resources.
- *Use the Structural Funds and national sources to foster capacity building and provide a step change in terms of the resources available for innovation* (human resources, infrastructures, support for business innovation, etc.).
- *Place greater emphasis on instruments that stimulate demand for innovation and innovation-related services*, including in the longer term. This implies some shifting from a predominantly supply-side, "science push" approach towards the demand side.
- In light of the pronounced decline in business expenditure on R&D, *review the relative success of all measures used so far (direct funding, tax incentives, etc.) to stimulate business R&D.*
- *Develop a better understanding of sectoral policies,* notably as regards PRIs with a sectoral specialisation (agriculture, health, energy, environment, etc.). Strategic alliances between agencies in charge of monitoring, supervising or implementing sectoral regulations and policies and specialised PRIs could provide an important opportunity. The adoption of European standards and regulations will be a major challenge – and can be used as an opportunity for innovation – over the next five to ten years.

Governance of universities and public research institutions

The current internal organisation of universities and PRIs presents obstacles to effective governance, and their funding arrangements are complex and fall short of international good practice. Moreover, the funding of universities and PRIs is fragmented. Salaries, investments and consumables are funded from different sources, based on different rationales. This is an obstacle for implementing coherent strategies and long-term planning. Moreover, because their faculties are very autonomous, the management and governance of most universities (including the largest, the University of Zagreb) are quite weak. Owing to the HEIs' and PRIs' funding patterns and inherently change-averse mode of governance, significant reforms have not been accomplished. Many of the measures and instruments introduced during the last decade have been incremental, leaving the underlying arrangements unchanged. Membership in the EU and the availability of SF resources will create opportunities to increase funding and improve the governance of public research.

The current state of fragmentation, especially in the largest, oldest and most significant universities, prevents the HEI sector from reaching its full potential and harbours risks. First, it tends to militate against "new combinations", in particular interdisciplinary approaches in education and in research. Second, as many regional (and societal) issues require a concerted interdisciplinary and multidisciplinary approach, fragmented institutional structures weaken institutions' ability to respond to regional concerns and thus to attract funding from industry. Third, the inherent limitations on the ability of the constituent units to co-ordinate efforts and programmes and to pool resources for the provision of common services leads either to redundancy or to uneven coverage (particularly when there are resource constraints) in support functions, such as

administrative, procurement, technical and student support services. An inefficient use of limited resources carries a higher opportunity cost in Croatia than in most EU countries, given that its development is at a crucial juncture. Fourth, functional fragmentation may discourage strategic planning on resources, the establishment of large research programmes, infrastructure investments, participation in major research initiatives, and more broadly, the achievement of "critical mass" in scale-critical contexts. Fifth, fragmentation is an obstacle to the development of a common mission, a sense of purpose and a clear identity. These are important for a university's ability to differentiate itself, increase its visibility, occupy a position in the national and international HEI landscape and consequently for its long-term success in an increasingly market-oriented sector. Finally, fragmentation complicates the improvement of governance through negotiated performance-based, future-oriented funding principles.

Comprehensive reform of the governance arrangements of the country's older universities seems overdue and will be essential if the universities are to fulfil their social and economic role fully. A major challenge for the government will be to negotiate a workable reform proposal with the old universities and their faculties and academies. A shared understanding of opportunities and, importantly, of the concerns that motivate the backlash against perceived "centralisation" will be essential to reach a widely accepted solution. Like all consensus-building exercises, success will hinge on a continuing dialogue and on the accumulation of trust among the various stakeholders.

Governance improvements will also require achieving a good balance in the division of responsibilities between the central government (MSES and agencies such as CSF) and the HEIs. As in other countries, the move to greater institutional autonomy has to go hand in hand with increased accountability. Typical governance instruments intended to increase accountability include monitoring of performance or outputs and the establishment of performance reporting, performance contracts or similar instruments. Such contracts increase accountability for performance without compromising the universities' intellectual independence. Such policy practices can be found in Australia, Canada, Ireland, New Zealand, the Netherlands, South Africa, the United Kingdom and the United States.

Croatia's PRI landscape is characterised by fragmentation (with the notable exception of the Rudjer Boskovic Institute). There are many organisations active in the humanities, social sciences, engineering, health and agriculture. A multiplicity of actors in a given area can be positive in that it can foster competition, diversity of approaches and independence in the provision of scientific results. However, in the absence of performance-based funding or of substantial competitive project-based funding there is little tendency to compete in terms of quality and relevance. Moreover, the fragmentation of capacities among several organisations may hinder collaboration and prevent scale-critical activities at national and international level. A move towards linking funding to performance by performance-based funding mechanisms would enable the PRIs to pursue their ambitious objectives with diversified sources of funding.

- *Strengthen universities by adapting funding arrangements according to international good practice, notably by implementing performance-based budgeting.* Performance-based budgeting should include:
  - budgetary autonomy in terms of financing personnel costs, as well as a comprehensive upgrading of their physical infrastructure and research equipment;

  - a concept of "performance" that takes due account of past achievements and plans for the future;
  - progress towards simplifying university management and consolidating governance in order to increase flexibility and responsiveness to changing demands for education, training and research.

- *Strengthen PRIs by implementing performance-based budgeting and related governance principles*. The main challenge here is to implement steering models – mainly by negotiating performance contracts – that will help strengthen public research by fostering: relationships with business firms and public institutions, mainly through more contract research and provision of related services (including training and consultancy); scientific productivity, not least through increased collaboration with the higher education sector; and international collaboration.
- *Use Structural Funds to strengthen universities and PRIs and support the reform process in terms of additional budgetary resources and improved governance.* Structural Funds provide an important opportunity to establish new research infrastructures with a well-defined research agenda, mission, target groups and governance. Ideally, these new structures should be placed in existing HEIs and PRIs with well-defined links to the wider system. Training of young researchers should have high priority.
- *Encourage individual universities to specialise in various types of links with industry*. While some universities may be better suited to cater to the needs of larger firms with their own R&D labs, others may be better able to provide services to SMEs.
- *More emphasis should be placed on measures to improve the relevance of graduates' skills,* such as the development of curricula, industrial placements and the co-funding of postgraduates. The provision of well-qualified graduates is, by far, universities' most significant impact on the innovative capabilities of Croatian firms. Training qualified personnel for research and innovation is also a very important function of PRIs.

Evaluation

Evidence on the efficiency and effectiveness of publicly funded innovation is mixed. Croatian scientists are more "productive" than their peers in comparable countries. However, Croatian scientific publications and patents receive fewer citations than those of comparable countries. Low international impact may indicate the weak relevance and quality of knowledge outputs. Making evaluation a standard practice and linking it to institutional funding will increase accountability, help to strengthen high-performing entities, and may help identify changes needed to improve performance.

In recent years, Croatia has made strides in the introduction of formal evaluation mechanisms, most notably with the establishment of the Agency for Science and Higher Education. ASHE is in charge of accreditation and quality assurance in HEIs and PRIs, as regards both education and research. Its commitment to international peer review, transparent procedures and willingness to learn from international best practices is encouraging. A tangible way of improving economic relevance is to involve industry representatives in evaluations of HEIs' education and research programmes.

When it comes to the evaluation of research and innovation programmes and support measures, however, it is fair to say that external evaluation mechanisms are still at an early stage of development. While some programmes have been formally evaluated, the practice is not systematic and the results of evaluations are not always made public. This limits stakeholder feedback and policy learning. It also represents a missed opportunity to improve the allocation of public resources. Lack of an independent actor with a programme evaluation remit prevents the accumulation of experience from a wide range of programmes.

Objectivity and independence are important, and greater use should be made of systematic measures, such as the relation between outputs and inputs, complemented by managed qualitative assessments involving panels of international evaluators. At the same time, evaluation practice needs to avoid excessive reliance on quantitative indicators.

- *Consider making the external evaluation of on-going and future programmes mandatory.* Evaluation results should be used as feedback in the policy cycle.
- *Put strong emphasis on the evaluation of institutions, their governance and management* in order to strengthen governance mechanisms and, eventually, performance.
- *Review existing evaluation arrangements to achieve a better balance in terms of the quantity and quality of research output* and more broadly the types of criteria applied.
- *Make use of the opportunities to improve the evaluation system and culture that the management of Structural Funds will provide*. The obligation to evaluate various kinds of proposals and to carry out mid-term and final evaluations can be instrumental in establishing a rigorous evaluation system that can spill over to other areas.
- *Consider employing "mixed teams" of national and international evaluators* as a way to transfer know-how on evaluation.
- *Consider creating a platform involving researchers, policy makers, and practitioners* charged with programme implementation to exchange experience with and results of evaluations.

Fostering innovation in the business sector

Croatian companies in general (and SMEs in particular) are less likely to engage in innovation than their counterparts in EU countries and, even when they do, they devote few resources to it. To some extent, the propensity of businesses to innovate systematically is constrained by characteristics of Croatia's industrial structure, such as firm size, sectoral distribution and the relatively low overall share of employment in knowledge-intensive sectors, while the share of employment in knowledge intensive market services is high. However, business-sector R&D spending is low by international standards even among countries with a similar industrial structure. The relative decline in the intensity of business-sector R&D (ratio of R&D expenditure to GDP) and the low level of business R&D expenditure (BERD) reveal a widening gap with many advanced and emerging economies. In addition, internationally comparable evidence on co-operation among companies on innovation places Croatia last among a group of similar countries. Government support to business in terms of direct R&D funding is

exceptionally small by international standards and the situation does not improve much when adding public support through tax incentives.

The two leading industries (telecommunications and pharmaceuticals) account for about a third of all business expenditure on R&D, while the rest is dispersed across various industries. (The structure of exports presents a similar picture.) "Technological productivity" as measured by the ratio of patents to BERD is low by international standards. Croatia's modest patenting record is not simply due to its small size but is also related to structural and institutional factors such as the lack of MNE headquarters, the prominence of public research in the research system (and its mode of governance), the intensity and quality of linkages between innovation system actors, and the appeal of intellectual property protection arrangements.

The combined presence of high scientific productivity and researcher cost efficiency (especially in comparison to older EU members) indicates that Croatia holds some attraction for business-funded R&D. Indeed, in terms of the R&D operations of MNEs, Croatia is comparable to other countries in the region, even if these are low by EU standards. Croatia may thus have some potential to attract further funding from abroad. This will depend, among other things, on the ability of Croatia's STI policy to nurture clusters of excellence and provide the necessary incentives (see below).

Support for business-sector innovation has centred on the interface between public research and the business sector with a view to greater collaboration between sectors and the commercialisation of public research. This focus is evident in the overall balance of instruments employed and their relative funding shares, i.e. the dominance of incubators and technology transfer, mainly from public research and higher education, to the private sector, with a focus on promising technological areas.

The STI policy debate has conceptualised the binding constraint as a *weak interface* between science and industry. The contrast between perceptions of a strong science base and the evident absence of strong economic impact may have contributed to the emergence of this view. However, Croatian performance in science lags that of comparable countries. Crucially, innovation activity and capacities in the business sector are weak in a number of dimensions. Therefore, the balance of available evidence – the quantity and quality of scientific output, the rather high share of applied research in HEIs and the weak commitments of businesses to R&D and other knowledge-intensive activities – overwhelmingly supports the view that the binding constraint is not at the interface but *at the core* of public-sector and business-sector innovation capacities. Of course policy in support of the interface between public and business research has led to desirable outcomes too; the argument made here is that the impact of these outcomes may be greater if policy attention is focused on unleashing the accumulation of innovation capabilities across the system.

Overall, support for business innovation is characterised by a strong emphasis, and perhaps over-emphasis, on R&D-based forms of innovation, and more specifically on the commercialisation of public research and support for high-technology start-ups. This science-push and frontier-focused policy approach has been useful for parts of the business sector. It has however been less attuned to the needs of the majority of business firms that are at the critical transition point between no innovation and new-to-the-firm innovation and to the innovating minority that lacks the resources and in-house capabilities (in engineering, design, marketing and information technology) needed to move to new-to-the-market and new-to-the-world innovation. This imbalance is due to the orientation of the public research system, to the presence of significant resource

constraints for boosting capacity building, to the fact that innovation policy has historically been linked to science and to the sometimes inadequate contextualisation of policy thinking and instruments transferred from abroad.

Comprehensive support for business innovation, especially for the long-term accumulation of in-house innovation capabilities in a greater number and variety of firms, will have to address businesses and their needs more directly, be better endowed, and make more extensive use of policy instruments. To give an indication of the challenge ahead, public support for business sector innovation will have to increase by at least an order of magnitude just to match the commitments of other new EU member states.

- *Increase government support for business innovation in general, while improving the policy mix and delivery of support.* Support should be widened to include non-R&D-based forms of innovation (such as organisational, marketing and services innovation) and to cover a wider range of innovation-related investments. Public support for knowledge-intensive employment (researchers, but also specialists in design, engineering, marketing and information technology), for training and education (e.g. enrolment on part-time courses at university for business staff) should be considered. Support for service innovation could be further strengthened through a sectoral focus, such as green tourism.
- *Adopt a nuanced approach that takes account of the different needs of various types of companies* (size, sector, market orientation) at various stage of their development (start-ups to mature firms). This has implications for the way support is organised and delivered (economies of scale and scope).
- *Evaluate the effectiveness of major programmes, including tax incentives for R&D,* to establish the benefits and costs of these instruments and compare them with policy alternatives. With respect to tax incentives, it would be important to seek ways to minimise risks arising from the cross-border tax planning activities of MNEs.
- *Make the innovation dimension part of all public support measures for industry, including sectoral support.* Seek synergies between support dispensed using existing instruments and the adoption of EU regulations. Consider a more creative use of funds for recurrent public procurement needs to support sectoral innovation.
- *Strengthen the ability of Croatian companies to appropriate and commercialise knowledge* from within and outside Croatia, e.g. by providing technical and material support for participation in international collaborative R&D initiatives (such as the EU Framework Programme and EUREKA).
- C*oncentrate efforts on attracting FDI in knowledge-intensive sectors.* Experience from Ireland indicates that this can bear fruit if an independent FDI-promoting agency has sufficient executive autonomy, and if there are targeted investments in skills, a comprehensive labour market and regulatory reform, integration in international markets, and the harnessing of diaspora networks.
- *Consider the introduction of measures to support inter-firm (or firm-firm) networks,* possibly with a sectoral and/or supply chain focus, to facilitate spillovers between firms capitalising on various modes of innovation.

Strengthening links in the innovation system

University-industry collaboration, as measured by public-private co-publications per million population, stands at about 50% of the EU27 average. More encouragingly, business-sector funding of higher education R&D is slightly above EU and OECD averages. MNE subsidiaries in particular appear to value the capabilities of Croatian universities and have expressed interest in co-financing more doctoral students. However, such opportunities are often perceived as incompatible with current evaluation criteria for scientists. The share of business in the financing of R&D in PRIs is low, at about 5%, or about half that of HEIs. Over the longer term, linkages may be negatively affected by a decline in the prominence of engineering, as evidenced by the evolution of its relative share in scientific publications over the last decade. Improvements in other parts of the innovation system, including in human resources, support to the business sector and general capacity building, can be expected to affect linkages and knowledge flows.

Aside from a small number of MNE subsidiaries with R&D departments, the few resources devoted to research and innovation in the majority of firms limit the potential for systematic R&D and the intensity and quality of R&D and innovation linkages. Countries in which the business sector shows weakly developed innovation capabilities and a low propensity to invest in R&D and innovation typically face the challenge of overcoming a "low-level equilibrium" with little effective demand for and supply of innovation-related services and research. In such a "locked-in" situation – observable in many countries – public research institutions and businesses do not gain experience through mutual learning and co-operation with each other. Research institutions tend to remain disconnected from the domestic economy; at best they are linked to research institutions and enterprises abroad (e.g. via European programmes). This situation is not conducive to creating the localised spillovers and positive feedback that are characteristic of economies that thrive on innovation. A major task is to devise policies that foster the required in-house capabilities and nurture this kind of dynamism.

On-going efforts to strengthen linkages and alignment with the needs of the business sector should continue. It would be important to adopt a wider definition of university-industry linkages than has been used to date, one that goes beyond joint research projects, technology transfer and spin-offs to include continuous consultation on the content of skills, the introduction of "sandwich courses" with longer (typically one year) work placements, joint workshops, industry involvement in doctoral schools, development of professional doctorates with distinct criteria for advancement and tailored HEI study programmes for those already in employment (part-time/summer courses). Innovative instruments to capitalise on the unique production and design knowledge of multinational enterprises by way of government-sponsored and HEI-led on-the-job-training schemes at the premises of multinational subsidiaries can also be explored.

- *Use the EU Structural Funds as an opportunity to establish robust, long-term collaborative research and innovation capacities*. Attention to industrial and other fields of application that serve the needs and goals of the parties involved is critical.
- *Maintain, and where possible increase, industry-oriented research at universities*. At the same time, examine possible options for the creation of complementary organisations (either independently, as part of existing PRIs or in the form of public-private partnerships) focusing on the provision of innovation services for a wider range of firms.

- *Facilitate university-industry collaboration not only on formal R&D but also in education, training and non-R&D-based innovation.* The possibility of government-sponsored schemes for on-the-job training at the premises of multinational subsidiaries can also be examined.
- *Consider using bottom-up, competitive calls* to solicit and identify promising ideas and configurations or consortia.
- *Encourage the training of researchers for the business sector* with appropriate changes in the incentives for students, including the introduction of professional doctoral programmes.
- In particular, *review evaluation mechanisms and criteria for scientists* (from training to senior posts) to encourage collaboration with industry. Evaluation criteria and methods should be appropriate to a situation in which a large of share of collaboration for innovation may involve small companies whose innovation activities do not usually lead to intellectual property rights or scientific publications.
- *Take concrete steps to strengthen the standing of disciplines that are relevant to industrial innovation* in the country's universities and public research institutes.

Fostering critical mass, excellence and relevance in public research

Croatia's HEIs and PRIs conduct research on a wide range of subjects. However, engineering, and to a lesser extent, agricultural and environmental sciences and chemistry, biochemistry and pharmacology have undergone a relative decline. In addition, their publications are characterised by a rather poor (though improving) citation impact and a small presence in the top 10%. Croatia compares unfavourably in these dimensions, including with new EU member states of similar income per capita. The quality deficit of Croatian science appears to be at least partly rooted in institutional features such as the governance of the public research system and the incentives provided by criteria for evaluating researchers' performance. The Croatian science system needs to raise its ambitions and progress beyond the "minimum" criteria for accreditation and other *ex post* quality assurance processes put in place by ASHE towards the active pursuit of excellence.

Due to the low levels of resources, a lack of continuity and a suboptimal institutional and governance structure, Croatia currently lacks the ability to steer the innovation system towards more large-scale and long-term research programmes that can lead to the creation of stable research communities. Factors that have prohibited advances in research are inflexible budgeting arrangements, highly fragmented organisation, both within HEIs and between PRIs, and the absence of substantial performance-related budgeting at institutional level.

Moreover, during the last decade, in addition to the unstable and overall low levels of resources, budgets for launching programmes have been relatively low and mainly allocated to projects at the periphery of the institutions (incubators, spin-offs, technology parks) rather than to more long-term and large-scale research programmes at the core. Accordingly, neither the government and its agencies nor the research system have gained sufficient experience in handling large, long-term investments in research, except for a few, mainly physical investments. Notably, there is no substantial experience with instruments of the kind that have been established in many countries during the last

decade, such as competence centres, doctoral schools or excellence programmes (typically with 50-150 researchers over a period of seven to twelve years). A research centre is generally a well-co-ordinated unit of a number of teams, in terms of its thematic profile and coverage, career opportunities, mobility and international exchange, and a proper balance of core activities and resources and incentives for probing new opportunities. "Critical mass" is therefore more a matter of governance, management and leadership than of mere numbers.

Competitive funding has generally been low in both absolute and relative terms and has been volatile, especially during the crisis. CSF in particular has played an insignificant role as a source of funding. Somewhat uncharacteristically for a science agency, CSF's mission has focused on maximising the economic impact of science. In countries with strong innovation systems, it is typical for science agencies to aim, above all, at fostering scientific rigour and a culture of constructive scepticism. This is generally achieved by fostering both competition at home and international collaboration. The role of CSF will be to help bring about a shift in the balance of HEI and PRI funding towards competitive funding and to support a system-wide drive to internationalise. The success of this effort, however, will also depend on factors beyond the CSF's mandate, such as meaningful reform of HEIs and PRIs and implementation of performance-based principles in the allocation of their institutional funding, correct functioning of advisory councils, and full exploitation of the opportunities created by EU membership, especially with respect to success in the FP and the European Research Council (ERC).

A gradual expansion of doctoral education, with the establishment of doctoral schools, would set the stage for a comprehensive, long-term upgrading of research capacities. In addition, the training of young researchers can be directly linked with and made dependent upon investment of Structural Funds in research infrastructures and competence centres. PhD students and post–doctoral researchers are the preferred candidates for collaborative projects funded from European programmes, in particular the follow-up to the FP, Horizon 2020. A strengthened CSF would be the natural candidate for launching the doctoral school programme.

The current balance of higher education capacities between the major urban centres and other parts of the country is in line with expressed policy commitments to lessen regional disparities. Provided good practices are adhered to in evaluation, there is no reason to suggest that geographic dispersion is incompatible with academic excellence. Regions need development agencies or equivalent functions provided by incubators, business centres, chambers of commerce, etc. However, given the scale of resources available and the importance of proximity to industrial centres for economically useful innovation, policy makers should avoid excessive dispersion of resources for technological and other innovation support infrastructure (incubators, technology parks, etc.). In the Croatian context it is unlikely that the disadvantages of a strong dispersion of resources would be outweighed by its impact on endogenous regional growth. From this perspective, some clustering of investments on technological capacities near industrial centres, ideally in locations with good international links, would appear necessary. An important function of regionally targeted measures would be to connect and integrate innovation actors from across the country to the national and European institutional framework. In many instances regional agencies would play the role of a "first-stop shop" (rather than of a "one-stop shop") by providing access to various resources and related agencies.

Against this backdrop, the following strategies and measures seem appropriate, recalling that the introduction of performance-based budgeting and greater autonomy in HEIs and PRIs are important pre-conditions for acting strategically, i.e. for taking a more focused, long-term outlook, across institutional borders.

- *Use the Structural Funds to facilitate capacity building* for skills and education, as well as research, innovation and commercialisation. Take decisive measures to strengthen administrative capacity for project planning and management.
- As a rule, *invest in research infrastructure* (including buildings) *only when they form part of coherent long-term research programmes* of wide appeal.
- *Pay special attention to establishing more application-oriented research facilities* that are jointly operated by HEIs, and PRIs and, wherever feasible, business enterprises. A jointly agreed research agenda, a clear understanding of access for users, and training of young researchers should be key elements. Negotiated performance contracts are a proven instrument for balancing different requirements and act as a supportive framework for management. In general, the main focus should be on the attributes of centres rather than on a given sector, as the latter approach may lead to the selection of inferior candidates.
- *Address the imbalance between competitive (or project-based) and institutional funding and recast the mission of CSF* to aim, above all, for scientific excellence. Its mission will only be meaningful if CSF is sufficiently empowered in terms of resources to engage in a wholesale expansion of competitive support to science while not neglecting support for its industry-oriented portfolio of measures.
- *Support Croatia's participation in and benefits derived from the FP* (Horizon 2020) and the European Research Council using awareness campaigns, mock screening of proposals and coaching.
- *Implement doctoral schools in more advanced academic contexts*. This has proven a quite powerful instrument for establishing long-term research programmes (up to 12 years), performed by PhD students and supervised by their professors and complemented by specialised training, industrial placements and international exchange programmes.
- *Avoid excessive dispersion of investments in technological capacities as more resources become available.* In addition to existing measures to foster localised economic impact, use resources across regions to better integrate regional actors into the national and European institutional fabric.

Maximising the benefits from the internationalisation of R&D and innovation

Integration in international scientific and innovation networks and technologically advanced production chains is fundamental to the quality and impact of R&D and innovation, especially for a small country. Croatia has – on various accounts – made progress in the internationalisation of its innovation system over the last decade. However, it remains less internationalised than one would expect given its size, geographic location, and links to the EU. The low levels of personnel mobility from and to Croatia are a key concern as cross-border mobility is an important channel of international knowledge transfer. While the R&D activities of subsidiaries of MNEs in Croatia are comparable to those in other countries in the region, overall FDI stocks and trade volumes are below those of comparable economies. Research in universities is still

not as internationalised as in comparable innovation systems, and this is true in terms both of funding streams and of international research collaboration.

In fields such as environment, water, energy or food, regulations, monitoring and reporting are increasingly international or European. Creating links in these sectors between agencies and research communities in the PRI and HEI sectors will provide opportunities for international collaboration, including participation in Horizon 2020, and particularly in the biggest sub-programme, societal challenges, which represents 40% of its total budget.

- *Support the internationalisation of activities of existing and new programmes and instruments for public and business R&D*. Policy learning in this area can be fostered by participation in the EU's Open Method of Co-ordination processes. Reform of HEIs and PRIs should provide incentives for increased internationalisation.
- *Actively support the internationalisation of Croatia's businesses* by offering a presence and brokerage services in selected innovation hotspots around the globe. While a dedicated Croatian presence may be necessary in selected places, policy makers may also explore the possibility of sharing existing facilities of other EU member states by contributing to their costs.
- *Foster internationalisation in the arrangements governing universities and PRIs and incentives for researchers*. Performance-based budgeting and related performance contracts can relate directly to increased internationalisation in terms of income generated from contracts and grants, exchange of staff, co-publications, partnerships, etc.
- *Relate the internationalisation of R&D and innovation of specialised PRIs to their respective agencies*.
- *Favour "brain circulation" over "brain drain"* by linking international mobility schemes to existing or projected long-term training and research and innovation programmes (rather than to stand-alone mobility schemes), so that mobility fulfils a specific purpose (e.g. training in a specialised skill, experience with specific methods). Provide adequate incentives for repatriation. On the first instance this may involve re-establishing discontinued initiatives by the CSF.
- *Consider developing an explicit internationalisation strategy for R&D and innovation*. Such a strategy would complement the internationalisation impulse offered by EU membership, with efforts to open up to third countries, especially those with which Croatia has traditional ties (neighbours in the region and major export markets) and whose rapidly developing economies offer opportunities for R&D collaboration and innovation.

Table 0.1. SWOT analysis

Strengths	Weaknesses
• Geographic location on the Adriatic coast and at the crossroads of central and southeastern Europe; historical links with several developed and emerging economies. • Good macroeconomic performance prior to the crisis. • Improvements in framework conditions for innovation (while significant scope remains), including in the institutional landscape of policy actors in STI matters. • A well-educated population, especially in terms of secondary education attainment, and strengths in social sciences, law and humanities. • Some strengths or pockets of excellence in public research (universities and PRIs) and examples of collaboration between academia and industry. • Increase in scientific output (scientific publications). • Export strengths in a range of industries and a (small) number of relatively strong industrial R&D performers. • A fledging community of technology-oriented start-ups. • Participation in European Framework Programmes. • Good regional coverage of HEIs.	• Structural weaknesses of the economy exposed by the crisis. • Weak recent macroeconomic performance; wide productivity gap vis-à-vis European and OECD averages. • Aspects of framework conditions for innovation, including access to finance, administrative and regulatory barriers to entrepreneurship, and a lack of trust. • A skills profile that is unfavourable to innovation in the business sector, including lack of entrepreneurship and management skills. • An innovation system that is not centred on the business sector. • Insufficient resources, internal capabilities and outcomes as regards business innovation. • Shortfalls in the organisational set-up and governance of universities and PRIs. • Lack of incentives to develop excellent science. • Insufficient adaptation of international policy practices and instruments to national settings. • Inadequate division of labour between the government and the agency level. • Lack of sustained, longer-term political commitment to innovation, volatility of R&D budgets.
Opportunities	**Threats**
• Greater use of EU Structural Funds, but also national funds (including by reorientation of existing subsidies to industry) to upgrade innovation capabilities across the system. • Making innovation a part of sectoral policies. • Nurturing the development of a dynamic business sector that thrives on innovation. • Increasing the contribution of public research to social and economic development through additional resources and improved organisation and governance. • Develop inter-firm networks, both in Croatia and with companies in the EU as way to accumulate in-house innovation capabilities in Croatian firms. • Use innovation policy and a strengthened investment agency (in conjunction with other interventions) to attract knowledge-intensive FDI.	• Inertia owing to unwillingness to change. • Weakness in implementing strategies and policies. • Failure to prepare for increased competitive pressure following EU accession and from emerging economies. • Inability to mobilise financial and human resources for innovation and thus to capitalise on innovation as a source of growth and competitiveness. • Inability to reform the HEI or PRI sector and bring about needed improvements in efficiency, relevance and rigour. • Failure to generate tangible economic impact from increased investments in science, technology and innovation. • Reinforcement of tendencies towards rent-seeking entrepreneurship in the face of increased resources, e.g. via Structural Funds, unless accompanied by strengthened governance and accountability.

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