Transition Studies Review (2006) 13 (2): 395–413
DOI 10.1007/s11300-006-0115-y

Transition Studies Review

Venturing Jointly: Vienna's Innovation Economy

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Abstract. Vienna's role as Austria's largest innovative city-region depends upon many factors, of which a vibrant regional innovation system driven by joint research ventures is a key component. Between 1994 and 2002, various research groups located in the Vienna region participated in 7,334 research projects funded by the EU during the 4th and 5th Framework Programs. Organizations from this region were more likely than elsewhere in Austria to assume scientific leadership positions as project coordinators. The region specialized heavily in research concerning environment, information and communication technology, bio-technology, traffic, and general research topics. The region's most active organizations were concentrated in the city itself: universities, research organizations, small firms, and large firms were represented in a ratio of approximately 4:2:1:1. Among firms that participated, the largest ones dominated during the course of this period, although research participation by firms continually shifted more to small- and medium-sized enterprises. In terms of Austria, most research is concentrated in the about 30 most active postal-code zones, which in turn are dominated by the Vienna region. Over the full period, there is no evidence that Austrian research projects concentrated further and some types of research decentralized slightly. At the same time, the research participation of small- and medium-sized enterprises became more centralized within the Vienna region. The singular importance of stimulating further and more effective research in the Vienna region and its innovation system is obvious and these findings may be helpful in establishing policies that support key organizations, improve research infrastructure, and further stimulate the city's knowledge-generating system to ensure long-term innovation possibilities.

Important strides to promote a competitive and innovative economy for Vienna have already been taken, some of which are outlined in the report "Our commitment to quality – Innovation for Vienna: Strategy Plan for Vienna" (Stadtplanung Wien 2001),[1] two chapters of which reflect precisely the views of European Councils in Lisbon and Santa Maria de Feira, which resolved to

establish rapidly "... a European research and innovation area with a view to job creation and economic growth, in the context of sustainable development, with the ultimate goal of enabling the Union, within the next ten years, to become the world's most competitive and dynamic knowledge economy."

The Vienna plan is also to be understood in the context of details embedded in "Research Strategy Austria: '2.5% + plus'" and the National Research and Innovation Plan, which were developed in 2002 by the Austrian Council for Research and Technology Development. These mutually reinforcing strategies require strategic information and evidence to permit the formulation of sound policies and implementation actions that are geared to propelling Vienna to the forefront of an energized and globally vital European Union. Strategic actions require sound evidence about the actors involved in Vienna's innovative process, particularly small- and medium-sized enterprises (SMEs), large firms, universities, research centers and institutes. This article presents several concepts and related evidence seen as useful to promote these strategic actions.

Organizing concepts

Innovation systems

The concept of innovation systems applies unambiguously to the many competitive activities envisioned in Viennese and Austrian strategic plans regarding the Lisbon goals. Aćs (2002, p. 179) summarizes the main features of such systems as follows: "... all versions of the systems of innovation approach place innovation at the very center of focus. Technological innovation is a matter of producing new knowledge or combining existing knowledge in new ways, and of transforming this into economically significant products and processes. Many different kinds of actors and agents in the system of innovation are involved in these processes."

Although Aćs strongly supports the emergence and privileging of self-reinforcing regional innovation systems (RIS)[2], he acknowledges that RIS have not yet become widely accepted. While national systems of innovation continue to dominate the policy scene, "... sub-national areas are a more supportive underground for the development of multi-stakeholder networks and new forms of co-operation and relational exchange. But this has not deterred those who have a strong taste for national across-the-board interventions (and those who) emphasize the importance of the national network of institutions, acting as a system and providing the foundations and the underpinnings of the innovation system" (Aćs 2002, p. 171). Aćs apparently sees regional, national or supranational systems of innovation competing as distinct policy frameworks, although compatible divisions of labor and EU principles of subsidiarity could in principle be adopted to reconcile these

alternative approaches. Indeed, one can argue that the EC's Framework Programs (FP) function along these general lines, with national and EC funding supplying support for self-organizing agents in 2 or more EU countries who voluntarily join to conduct research, learn from each other, and generate the knowledge necessary for successful innovative practices at all levels. We shall return to a consideration of this framework in the section ''Joint research joint ventures''.

Fischer et al. (2001, p. 124) introduce their study of the Austrian innovation system by asserting: ''Territorially based systems of innovation build on spatial proximity in terms of both spatial distance and contiguity – as either regional [subnational], national or global systems of innovation. The central idea underlying territorially based systems is that the economic performance of territories depends not only on how business corporations perform, but also how they interact with each other and with the public sector in knowledge creation and dissemination.'' Not surprisingly, their findings reveal that knowledge production (as measured by patent output) is predominantly centralized in the Vienna region, while the outer portions of the region attain only average, Austrian-wide patenting levels. Vienna's hyperconcentration is shown to be strongly correlated with its local knowledge inputs, principally from university and research center sources. Perhaps the average (or lower) levels of knowledge production in the outlying portions of the Vienna region are responsible for comparatively low proportions of sales and output of products 3 years or newer by firms in those areas, which in turn were among several important factors behind the establishment and promotion of the Lower Austria Regional Innovation Strategy (RIS NÖ). More specifically, the need for developing RIS NÖ is based in part on the facts that ''... companies of the region (NÖ) do not sufficiently use services provided by institutions in Vienna due to the lack of information about the supply of technology and the lack of experience of the technology providers''.[3]

Lower Austria's stated dependence upon Vienna for innovative potential may reveal an implicit reliance upon the top-down innovation processes referred to earlier by Aćs, although we shall later see opportunities to broaden the RIS concept to a larger set of agents and collaborators.

Revilla Diez (2002) helps position a broader Vienna Metropolitan Innovation System with respect to those of Barcelona and Stockholm, particularly with respect to the role of research institutes and firm innovativeness. While all three metropolitan areas exhibited similar tendencies for value-chain networking among firms, research institutes in Vienna (like Stockholm) were more likely to work with large firms, perhaps along the lines of Schumpeterian Mark II innovation efforts[4], although Viennese institutes are seen by Revilla Diez to work in less significant ways than their Swedish counterparts.

A focus on large, Mark II firm innovation practices may reflect incentives among research institutes in Vienna to cooperate mainly with firms that help

enhance the institutes' own R&D capabilities, rather than helping firms make the transition into new, technologically intensive commercial fields. Relying on similar data, Rohn (2000) notes that Vienna's research institutes focus heavily upon certain technologies: information and communication technologies, materials science, environmental engineering, sensor engineering and measurement, and bio-medical engineering. Perhaps these favored technologies are difficult for smaller Mark I firms to enter and the reason why Mayer (2000) found that Viennese firms seeking new technologies more often rely upon national – and especially international – networks than those in the Vienna RIS.

Motives of firms in Vienna to cooperate in research networks include access to funds and planned entry into new technological fields; research ranks fourth of five possible options when Viennese firms indicate the types of networks with which they prefer to cooperate, implying other business-related needs are more important to the average firm. Rohn (2000) further notes that most of the research institute cooperation with firms is frequently informal, extensive and conducted at the precompetitive product innovation stage where research networks could play important roles.

The RIS is clearly a viable concept for advancing the innovation goals laid out by Vienna and the EC (Lisbon Objectives). Its essential features are well known and it provides a useful framework for further policy initiatives at several levels, particularly with regard to its core organizations, their innovative competences, and the emergence of productive and lasting innovative networks within the Viennese RIS. This article provides further detailed analyses of network dimensions in time and space and provides a working understanding of the innovative trajectories open to future policy influence. The innovative networks of greatest potential value to the Vienna RIS are joint research ventures.

Joint research ventures

The second important concept used in this analysis of Viennese innovation is that of joint research ventures (JRV)[5]. These are a subset of joint business venture activities, specifically "research and development operations" engaged in by 2 or more firms, which extend considerably typical joint business activities such as buying and selling, developing resource or production operations, and engineering or construction operations (OECD 1986). In their critical review of the literature, Caloghirou et al. (2004, p. 3) focus on "a certain kind of cooperative R&D agreements, those involving the generation/adaption (but not simple exchange) of new technological advances, broadly defined to include both pre-competitive (generic) and development (close to market) knowledge as well as the definition of standards". Firms often seek to form networks of such ventures with other firms as means of

ensuring future commercial success, although the precise factors differ broadly across industries and firm circumstances, and few generalizations are possible (Hernán et al. 2003). However, large firms, firms that routinely patent, or firms receiving government support to innovate are shown by data from the second Community Innovation Surveys as more likely to form collaborative links with universities and research laboratories, while R&D-intensive firms and "radical innovators" seek only certain forms of knowledge (Mohnen and Hoareau 2002). JRVs are said to have accelerated after issues of competition and intellectual property rights were sufficiently (but not totally) resolved to reduce legal barriers to their formation, thereby permitting motivated firms more easily to acquire and create new knowledge, improve their technological and organizational capabilities, and continue existing or accelerate research efforts (Caloghirou et al. 2004) through JRVs.

The self-interest of firms to form JRV networks and accelerate innovative research is seen to have "underlined the establishment of a formal science and technology policy in the European Union during the 1980s, very much based on the support of collaborative R&D through the *Framework Programmes* for Research and Technological Development" (Caloghirou et al. 2004, p. 8). The EU's choice of JRVs to accelerate collaborative research apparently emulates: "[O]ne of the features perceived to contribute to the USA's success in innovation and job creation has been the health of new SMEs in new industries: Silicon Valley has had a particularly strong influence on European policy makers. *This fitted well with the collaborative imperative for the Commission. Collaboration between SMEs, and between SMEs and other actors in the innovation system, would at the same time achieve scale economies, reduce 'duplication' of research efforts, and promote diffusion of technologies and their exploitation*." (Caloghirou et al. 2004, p. 166; italics added).

Analytic approach

The EC's Framework Programs (FPs) represent a continuing effort to stimulate firms and innovation systems throughout the nations and regions of Europe through JRVs, which have consequently been the subject of many research efforts. This study taps the same general source of data[6] about JRVs in Austria, with specific emphasis placed on Vienna's innovation system. As we shall see, although this dataset consists of anonymous participants, which reduces our opportunity to focus on certain details or to examine shifts in identity over time, it is rich in other ways. In particular, we know the postal codes of each Austrian participant, which permits very fine-grained spatial analyses of where JRV networks and nodes are located in Austria. We also know the type of node, in terms of organization, so that firms of various sizes, universities, research centers, and government agencies, etc., are clearly distinguished. Since the data were collected during the 4th and 5th FP periods,

our data of "call dates" measures when any participant responded with a project. This means we have a general time-ordered data series, which permits the tracing of selected time-dependent features of JRV networks and nodes (for definitions of specific terms, see Table 1). The projects are identified by participants who received funding and those that did not, which ensures a full count of all active innovation-seeking JRVs. Comparing funded to unfunded JRVs also permits one important measure of success. Other types of success can be measured by amounts and shares of funds awarded to JRVs or by nodes that serve as project coordinators. Finally success can also be measured by repeated involvement in projects, i.e., continuing involvement or multiple participations in JRVs over time. These projects can be characterized by any combination of the above features that describe their individual participants.

In addition, the projects around which JRVs are organized are further characterized by permitted study topics and call features, which we have consolidated somewhat to simplify analysis and focus on themes of primary interest to Vienna. While other research activities in Vienna and Austria could result from independent initiative or the support and incentives provided by various Austrian or other EC programs, the comprehensive coverage of FPs ensures a representative sample of such networks,[7] and doubtless many of the same participants who join other JRVs are included.

The relationship between the various innovation systems in which these JRVs are embedded and the networks among key agents thereby produced is

Table 1. Glossary of defined terms

Concentration (of research): relatively high density of total project *participations* in Austrian postal-code areas.
Coordinator: individual named at one *JRV node* who is officially responsible to EU for coordination of specific *Framework Program project* and member contributions.
Dispersal (of research): relatively low density of total project *participations* in Austrian postal-code areas.
Framework Program: a group of specifically defined research topics and priorities supported financially by the EU in particular years.
Joint research venture (JRV): a purpose-specific network of eligible research organizations that pursue EU *Framework Program* funding with research ambitions concerning topics of mutual benefit.
Mark I, II: types of innovation and innovative organizations associated with development theories of Josef Schumpeter; see text for elaboration.
Node: Uniquely defined and anonymously coded organization that participates as a *JRV* member in one or more *Framework Program* projects in Austria (see *participant*).
Organization type: specific function that characterizes each unique *node* (e.g., universities, SMEs).
Participant: a specific *node* that serves as a member of a specific *JRV project* (see *node*).
Participation(s): 1 to N occasions when a specific *node* is involved in 1 to N *JRV projects.*
Project: a focused set of research activities conducted by a specific *JRV* with the EU *Framework Program*.

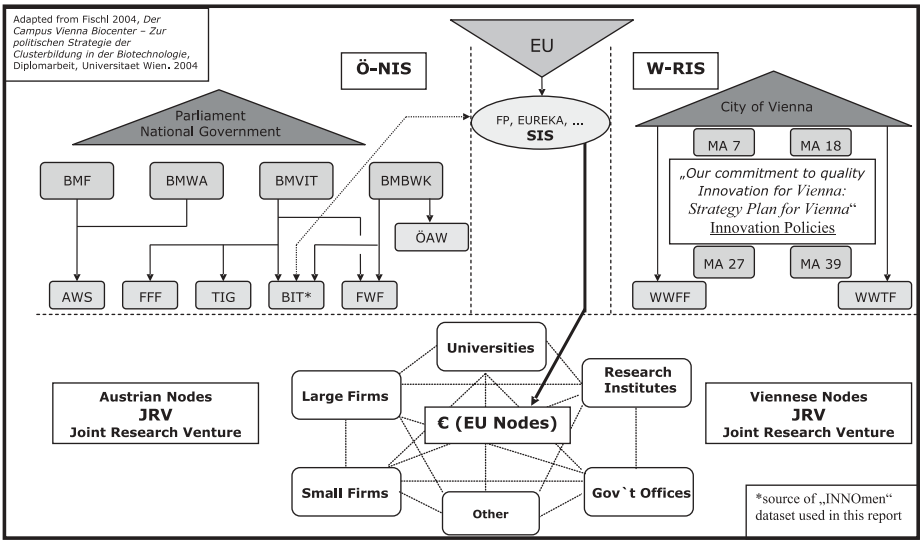

Fig. 1. Vienna RIS

illustrated by Fig. 1. The findings and results discussed at length here are intended to help further develop sound innovation policies for Vienna, although occasional points will also refer to policies at the Austrian or EU level innovation systems. We adopt without change the boundaries of the Vienna RIS used by other scholars (Fischer et al. 2001, Revilla Diez 2002, Mayer 2000, Rohn 2000) mainly for comparative purposes, although the recently organized Lower Austria RIS constitutes a larger and – arguably – an administratively more logical territorial unit.

Outline of study

A principal feature of this study is its heavy reliance on the factual features of the JRVs that constitute and help drive Vienna's innovation system. Therefore, much of what follows consists of analyses that describe JRV effects within the Austrian and particularly the Vienna innovation systems.

The first analytic component is an overview of the basic JRV structure, which includes key definitions, magnitudes, temporal trends, and spatial distributions. The following section focuses heavily on Vienna, with more detailed evaluations of basic structural features as related to core innovation system concepts. The third section deals with organizational capacities for innovation by categorizing the actors in the JRV according to the Mark I and Mark II classification. The final section examines some selected JRV network features.

Basic JRV structure: research projects, participants, participations

In a typical JRV sponsored by the EU, two or more eligible organizations apply for FP funds to conduct joint research, only a fraction of which are granted. Each project is a unique approach to a specific EU "call for proposals" to organize a project on some predefined topic. Unfunded proposals often bring together JRV partners who reapply or engage in non-EU-sponsored project activities.

The data set used here considers all the 4th- and 5th-FP topic calls that resulted in projects with at least one Austrian participant. The total data set includes 10,589 projects in which 3,885 unique Austrian participants were involved, about 53% of the total during the 5th FP (1998–2002) and 47% during the earlier 4th FP (1994–1998). The average project between 1994 and 2002 involved 2.72 participants. Since each unique participant can become involved in 2 or more distinct projects over time, the total number of "participations" necessarily exceeds the number of projects; each project averaged 1.35 participations. The most active anonymous Austrian participant was involved in 119 different projects, which is equivalent to 119 participations. The comparable figure by single participant in Vienna is 88.

The organizations most often involved in research projects, as measured again by project participations in Fig. 2, were universities and research institutes, followed by SMEs and large industry, which are relatively more prevalent in Austria. Thus, formal research organizations dominate both the Austrian and Viennese innovation systems, although the greatest growth potential probably lies with firms, particularly SMEs, since the number and size of formal organizations are relatively fixed in number. Overall, of the total project participations in Vienna (7,334), universities accounted for 3,010, while research institutes were involved in 1,559 projects, small firms participated in 945 projects, and firms employing more than 50 workers participated in 877 projects. It is important to remember that some projects may include 2 or more Viennese organizations.

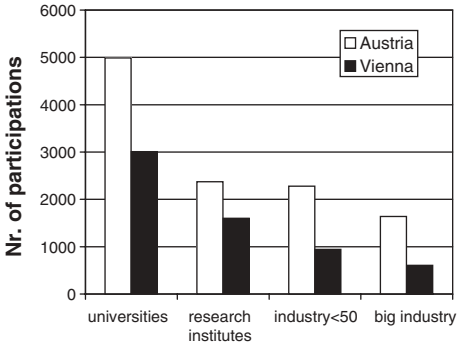

Fig. 2. Participations by major organizational groups for Austria and Vienna

Another general feature that deserves attention in this overview is the spatial distribution of JRVs. Figure 3 lists the major postal codes (and large place names) in which the most active participations occurred. The clear dominance of the Vienna region is shown, including specific district subtotals, but equally clear is the very strong representation by the Graz region, in which one postal code recorded the largest single number of participations. Other cities also show strengths (Innsbruck, Salzburg, Linz, Steyr, Klagenfurt, and Leoben); low levels of project participation are evident in other smaller peripheral regions throughout Austria.

Finally, proposals must compete for funding: skilled peer reviewers assess each proposal's strength relative to EU priorities to reach a final award decision. Figure 4 summarizes the major outcomes for Austrian project participations:

- not funded (the majority of projects),
- reserve listed (eligible if initial program funds remain unallocated),
- funded projects.

It also compares these outcomes by organization of participant. Clearly, universities are seen again as the leading JRV agents, having more funded and unfunded projects. The second-most frequently funded organizations are SMEs, although their unfunded projects rank third, which indicates a slightly higher SME success rate than for research institutes, which stand in 3rd position by funding success. The fourth organizational type most frequently funded and unfunded are large (>500 employees) firms. Innovation systems typically depend heavily upon active research organizations to generate basic findings, which can be appropriated, modified, and commercialized by firms

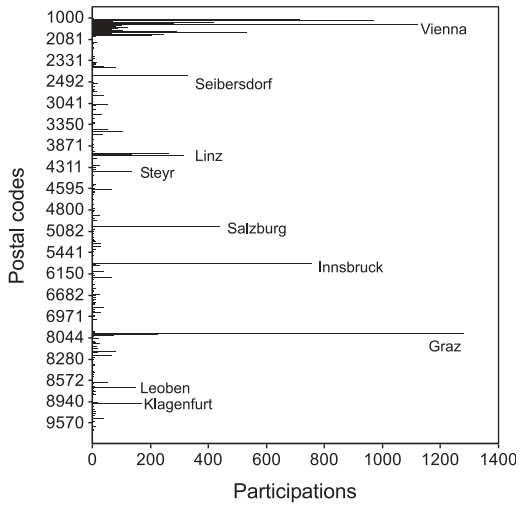

Fig. 3. Total participations per postal code (largest named)

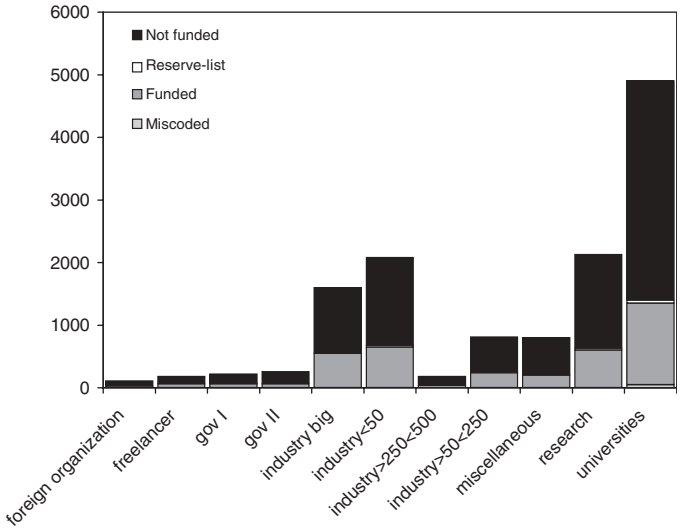

Fig. 4. Total Austrian participations per organizational group by funding status

of all sizes, although Mark I and Mark II innovation mode differences can push results of the innovation system in some rather than other directions. We will examine this potential in later sections.

Vienna's joint research ventures: comparative innovation evidence

The scale and scope of Vienna's JRVs relative to Austria's total are significant and important. This section describes in further detail Vienna's general importance to the Austrian innovation system in terms of funds supplied by the EC FP, the organizational coordinators who manage the funded projects, and capacities to commercialize or seize upon innovations.

During the 4th and 5th FP periods, Austria received about EUR 429 million from EC sources, of which EUR 204 million was spent on projects that had one or more Vienna RIS participants. The four most important organizations and their percentages of combined funding in Austria and Vienna, respectively, were as follows:

Universities	Austria, 35.5	Vienna, 42.9
Research institutes	Austria, 16.0	Vienna, 21.7
Big industry	Austria, 19.7	Vienna, 12.0
SMEs	Austria, 14.2	Vienna, 11.1

Universities and research centers together accounted for nearly two-thirds of all Viennese JRV funds, and these organizations also captured relatively more funds because they received higher percentages of budgets requested than their Austrian equivalents (although Austrian SMEs and big industries

received higher percentages of their requested budgets too).[8] There are comparative advantages for big firms and SMEs in the Austrian innovation system; in contrast, the Vienna innovation system has comparative advantage in universities and research institutes. The data available permit some further distinctions in terms of comparative program advantage: of 33 specific EU programs for which funding data are available, the Vienna RIS captured relatively more funds (109% to 1012%) in 15 program areas than the Austrian NIS, while the Austrian NIS demonstrated similar comparative funding advantages in 18 different EU programs.[9]

Capturing "coordinators" is a second major resource worthy of mention, since coordinator organizations often receive higher budgets, are more visible to EC officials and outside observers, and help build long-term capacities to generate or participate more heavily in future JRVs. How does the Vienna RIS compare with the Austrian NIS? With respect to the ability of Vienna RIS organizations to capture coordinator positions relative to Austria, universities (19.6 v. 18.2), research centers (24.2 v. 22.6), big industries (16.0 v. 11.8)) and SMEs (22.4 v. 20.9) in the Vienna RIS had higher percentages of coordinators than their Austrian counterparts. Vienna thus supplies disproportionately more of the managerial leadership in Austria's JRVs. The comparative advantages of each from a managerial perspective are shown by Vienna's higher yield of coordinators in 18 distinct program areas, while Austria's coordinator yield is higher in 15 programs.

The nine largest program subsets of the 33 EU programs available are shown in Fig. 5, the importance of which is measured by the number of Austrian and Viennese participations. Environment, information and communication technology, and general research topics account for the largest number of participations, while Vienna shows additional comparative strength in bio-technology and traffic research. These topics also reflect degrees of absolute advantage that represent the research base from which future JRV projects are likely to emerge.

Organizational capacities for innovation

Present and future JRV projects are important to the Austrian and Viennese innovation systems as sources of ideas that can be commercialized and exploited by firms within the industrial system. As mentioned earlier, innovation systems are characterized partly by the kinds of firms and organizations most active within them. The organizational detail discussed above shows SMEs and big firms to be far less active in EU-funded JRVs than universities and research institutes, which reflects the latters' primary function, their dependence on such funds, and their key role in the generation and development of basic innovations. The importance of universities and research centers to the Austrian and particularly the Viennese IS cannot be

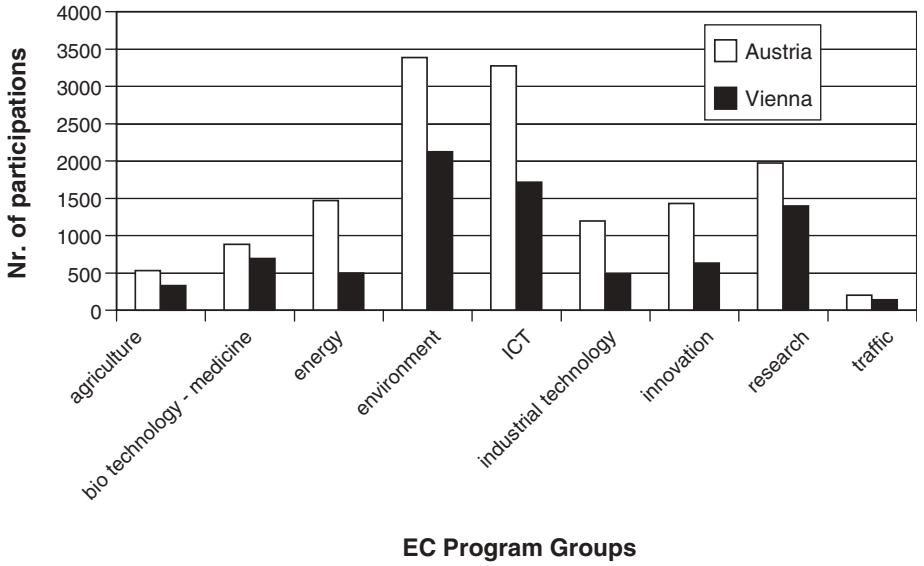

Fig. 5. Austrian and Viennese participations by EU program group

exaggerated.[10] Exceptional care must be taken to preserve core capacities during the present period of dramatic university reform. The Bologna process, managerial independence combined with financial dependence of universities, intellectual property issues, and merit-based scientific procedures must be addressed from the perspective of innovative capacity-building, to preserve and enhance the universities' research function during periods of rising instructional requirements.

To get a better idea of the commercial direction or trajectory of the Austrian NIS and Vienna RIS, we can compare the participation of SMEs with that of big industry firms in projects in which firms are eligible partners. Mark I innovation regimes rely mainly upon technological and product breakthroughs brought about by "creatively destructive" small firms and entrepreneurship, in contrast to Mark II regimes, which feature steady, gradual, and managerially guided accumulations of technological innovation around established industries, products, and large organizations.

Therefore, we can examine the proportion of Mark I versus Mark II type firms in JRVs to see which dominates at any given moment or over time. The long-term trend (if any) would yield valuable clues about future directions and possibilities. Taking SMEs as a percentage of all firms in projects provides a rough Mark I index. For the relevant 383 Viennese projects, 23.5 to 43.3% of participating firms were SMEs (median project/firm participant), while comparable median figures for Austria's 2,300 projects were 37 to 39.3%. These proportions indicate that both innovation systems are geared much more heavily to Mark II innovation patterns that favour large firms, which

reinforces points made earlier by Revilla Diez (2002). Large firms have more resources to dedicate personnel for JRV participation and fund internal R&D units to extract and apply available knowledge, so perhaps it is not surprising they have figured so prominently. In contrast, SMEs tend to be less stable, highly volatile in their commitment to innovative behavior, and may have difficulty sustaining innovative activities over time, particularly after having initially established a market niche and competitive product line. However, both the EU and Austrian authorities responsible for FP participation have worked hard to market research opportunities and offer support for SMEs. Therefore, it is important to detect whether these efforts have been repaid and whether there may have been a shift that favors Mark I-type innovation regimes.

A pronounced move toward a Mark I innovation regime appears to have occurred for Austria and Vienna. Figure 6 shows the cumulative proportion of all industrial representation in projects over time, as measured by the project call dates. The first few periods reveal rather unstable proportions until sufficient observations are available to "smooth" the cumulative totals, but the pattern is clear: median SME participation rates in Viennese JRVs consist of early period rates in the mid-30s, which then collapse to low 20s, but rise to about 43%. The same general pattern is true for Austria (not shown), which starts in the high-30s, collapses back to mid-20s and then rises to 44% cumulative proportions. Both patterns reveal a marked improvement in SME participation, particularly Vienna's remarkably strong rise in SME nodes, which is all the more remarkable considering that the Vienna RIS is dominated by universities and research centers. This may imply that SMEs and Vienna's strong research-based organizations are learning how to work more effectively together.

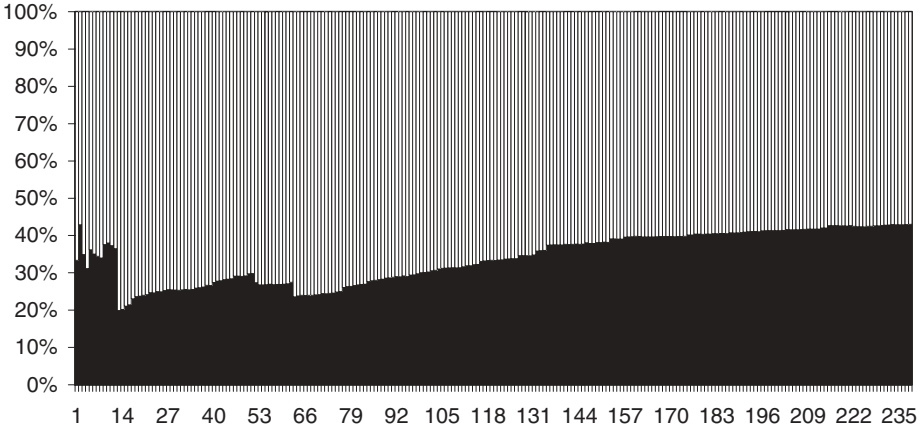

Fig. 6. Mark I (■) and Mark II (□) cumulative proportions – total Vienna

These proportions and shifts do differ by program area: environmental JRVs were strongly dominated by SMEs (60%) from the beginning and remained so, while bio-technology JRVs remain dominated by large firms (about 90%), although relatively sharp end-of-period increases of SMEs in bio-tech projects can be noted.

The implications of strong secular trends toward Mark I, SME-based innovation for future R&D policies, and innovative practices at national and Viennese levels are obvious and deserve close attention.

Central function of Vienna RIS innovation engine

The large size and apparent significance of the Vienna RIS within the overall Austrian NIS logically leads one to assume that it functions as the country's principal innovation engine. Although we have already noted an overall division of labor and evidence of Vienna's specific comparative advantages, there remains the question of Vienna's overall positive influence on other parts of the total innovation system. If indeed it does perform this function, then there may be grounds for supporting and enhancing an engine that yields benefits beyond its borders.

To examine this possibility, we devised some general "center–periphery" tests.[11] First, every Austrian postal code is ranked in terms of its total JRV participant nodes, where the postal codes with the greatest total of nodes (mainly Vienna, but also Graz) are ranked most central and those with the fewest nodes are ranked peripheral. The average postal-code rank for sub-groups of participating nodes can then be plotted for the projects in which nodes participated (Fig. 7). Higher average rank node size for any period would indicate (static test) a modal participant is located in more peripheral nodes, while smaller rank size indicates participants are located more centrally.

If the postal code ranks of participants remain relatively constant across time periods (dynamic test), we can say there is no tendency for dispersion of innovative activity toward the periphery or for concentration at the center. However, if ranks decrease or increase over time, then participation has further concentrated in central nodes or dispersed toward the periphery. Obviously, there is a scattering of nodes above and below the average rank at any particular call date, which measures the central tendency of JRV participants. Figure 7 reveals an overall dynamic formed by the many call-date mean values that oscillate mildly in cubic form around the grand mean (30+ most concentrated postal codes).

Since all JRV participants can be characterized by various features, including type of organization, funding status, and program type, etc., much can be learned by testing specific characteristics of nodes. To understand better the directions of the underlying dynamic (dispersing versus concentrating tendencies), we fit time-plot lines of postal-code ranks, using linear, quadratic,

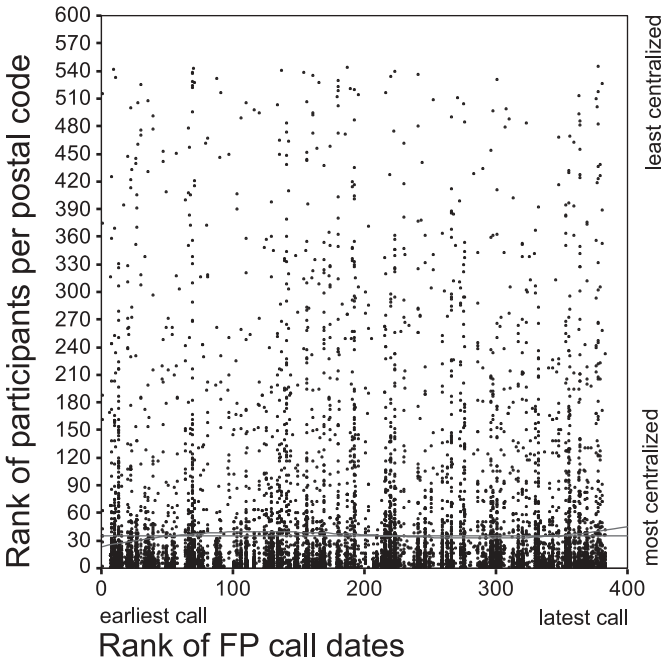

Fig. 7. Austrian participations over time and postal code (mean/cubic fit shown)

or cubic fits to determine general directions. We learn that multiple participant nodes are more spatially concentrated than coordinator, total, or single participant nodes; unfunded nodes are more spatially concentrated than total or funded nodes. We see Austrian nodes that participated more than once without funding are the most centrally concentrated (mean postal-code rank, 25), which compares with the Vienna RIS mean rank of 14 for multiple-participant nodes. At the same time, funded nodes that participated only once were the most peripherally located: Austrian mean rank of 105 and Vienna mean rank of 36.[12]

The second type of evidence indicates whether nodes were becoming more concentrated or dispersed between 1994 and 2002. Participating Austrian nodes dispersed in early periods, then reconcentrated somewhat mid-period, and finally began to disperse again. Multiple participants became a bit more peripheral at an early stage but then began to reconcentrate again. Path dependencies that favor initial concentrations, learning curves of repeated JRV participation, or growing spillovers among JRV organizations (e.g., SMEs and universities) within Austria's most central nodes may share some responsibility for patterns of reconcentration.

Following the same procedures, the center–periphery features of Austria's main topics can be examined. Total research topic nodes are the most heavily centralized (mean rank, 12), while innovation and energy are the most

peripheral (mean rank, 52). Energy nodes continue to disperse over time, as do environmental nodes, both of which are based upon terrestrial and resource-extensive technologies; on the other hand, information and communication and innovation project nodes show characteristic dispersal-concentration-dispersal reversals. No major FP topic is shown to be concentrating further in Austria, although the general topic "research" remains the most concentrated, depending as it does on fixed, centralized research units. Nodes associated with approximately 70% of project topics are gradually dispersing toward the periphery.

Within the Vienna RIS, general research topic nodes are dispersing slightly, while bio-tech and environment topic nodes reversed their early concentration tendencies and have dispersed a bit as well. Industrial technology, which is researched in the most peripheral Vienna RIS nodes, in the beginning concentrated somewhat, then dispersed toward periphery, and has begun to reconcentrate slightly again. The other FP project topic nodes show no tendency toward concentration or dispersal over time, although funding success of traffic and bio-tech nodes and multiple participants in research and environment projects are dispersing somewhat within the Vienna RIS. These slight tendencies might indicate opportunities for future regionwide cooperation within the Vienna RIS, perhaps along the lines envisioned by Lower Austria's Regional Innovation Strategy (RIS NÖ). Of the four principal organizations, the universities (mean, 6) and research centers (mean, 14) nearest the Viennese RIS center are by far the most frequent participants in RJV nodes, even though these nodes are few and remain anchored in relatively central places; accordingly, further dispersal of node activity is very unlikely. SMEs are the most peripheralized (mean, 38) JRV nodes, which indicates their important role in the dispersal of JRV research, but they show no further dispersion; successfully funded SMEs actually show greater concentration over time. Large firms (>250 workers) near the Vienna RIS periphery (mean, 28) are also active JRV nodes, which are becoming somewhat more peripheral, particularly those that are funded. This indicates that successfully funded SMEs are locating closer to core research capacities of the Vienna RIS, while successful large firms are doing exactly the opposite.

Different segments of the Austrian and Viennese innovation systems are becoming simultaneously more dispersed or more concentrated, depending on the type of research topic investigated by JRVs and the organizational nodes that constitute the JRVs. Vienna is clearly the innovation engine for certain kinds of technologies and topics, in which it holds comparative advantages relative to other Austrian regions. At the same time, other Austrian regions are important contributors to JRVs concerning topics and organizations in which Vienna lacks advantage or competence. Policies adopted at national and regional levels should closely monitor and leverage

complementary advantages to effectively support innovation efforts suited to the emergence and successful functioning of RJVs.

Conclusion

Vienna remains the principal engine of JRV research and innovation in Austria, capturing large shares of all Austrian projects, funding and management. Its organizational strengths lie in traditional university and research center capabilities, although rapidly restructuring universities will require concerted strategic attention at national (ministerial) and local (City of Vienna) levels to gain maximum effectiveness. At the same time, SMEs have emerged as increasingly frequent and valuable partners, perhaps learning how to work effectively with Vienna's principal research partners and how to capitalize commercially upon intellectual properties within Austria's globalizing business model. In every type of JRV organization, Vienna supplies disproportionate shares of leadership in the form of project coordinators. The Vienna RIS appears to continue developing its demonstrated excellence in information and communication technology, environment, traffic, and particularly bio-technology, but also appears open to developing emergent capabilities within its key organizations.

JRV-based research and development should itself continue to receive strong attention – particularly internationally organized JRVs – since this mode of research and innovation is capable of spreading capacities at many levels and in many regions simultaneously and enables learning about new opportunities far more rapidly and effectively than single-centered efforts. Promoting Vienna as the base from which such efforts originate should be among the most important projects as the City of Vienna continues to update and expand its strategic plans for an innovation- and knowledge-based economy. Shift in policy emphasis from patron-ministry to host-city has repaid efforts handsomely in other countries and regions and holds much promise for Vienna and its universities.

Notes

1 http://www.magwien.gv.at/stadtentwicklung/strategieplan/strategieplan2000/stratplan_engl.htm?S0=commitment&S1=quality#P0; "Perspectives for the economy and the labour market" (chapter 2) and "Promotion of science, education and culture" (chapter 3).

2 Regional innovation systems are a "network structure based on reciprocity and trust (which) is a self-reinforcing mechanism for it breeds trust and reciprocity, thereby increasing the social capital and generating increasing returns" (Aćs 2002, p. 173).

3 http://www.ris-noe.at/cwa/start.jsp

4 Mark I innovation modes are said to summarize Josef Schumpeter's early characterization of entrepreneurial efforts to innovate radically new products and technologies, while Mark II modes represent Schumpeter's later view of the cumulative possibilities of exploiting in-house technologies and product development by large firms.

5 We refer throughout to points from the well-developed research joint venture literature, but substitute the term "joint research ventures" in our discussions to emphasize (a) spatial networks and regional environments of JRVs, (b) non-firm JRV participants (universities, research institutes, governments, etc.), and (c) knowledge, innovation, or technology production of JRVs in innovation systems.

6 Complete details of the original data source "INNOmen", adjustments, assumptions, and structure are available in the interim report, which is available as a reference annex at the SRE website (http://www-sre.wu-wien.ac.at/VCIE_Interim_Report.pdf).

7 Although Austria's National Research and Innovation Plan estimates that such funding accounts for no more than 10% of total Austrian R&D spending, JRVs constitute the most tangible evidence available of interaction networks between all the principal agents.

8 The organizational division of labor between Vienna and Austria applies to relative funding success. For further details of financial capture ratios by organizational type and program area, see Tables 15 and 16 at http://www-sre.wu-wien.ac.at/VCIE_Interim_Report.pdf.

9 For specific program details, see Table 17 at http://www-sre.wu-wien.ac.at/VCIE_Interim_Report.pdf.

10 While policy responsibilities for university support has traditionally remained within relevant Austrian federal ministries, the City of Vienna has rapidly and perhaps somewhat unknowingly become dependent upon university research and instructional outputs for its own economic vitality and has therefore acquired incentives to develop suitable "university-friendly" policies accordingly.

11 The tests are both static and dynamic. The static test is an index of how central or peripheral JRV nodes are for a specific time period. The dynamic test examines whether JRV nodes are concentrating (toward the centers) or dispersing (toward the peripheries) over the full time period. We attempt to use these terms systematically in the discussion that follows.

12 Higher mean peripheral ranks are logically expected for Austria and lower mean central ranks for Vienna, since Austria includes all postal codes, while Vienna includes only the postal codes of its RIS.

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