2 Innovation and Technological Change: An Austrian-British Comparison

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Despite a growing body of empirical evidence that demonstrates the nature of spatial variations in innovation and the adoption of new technologies, at the time this chapter was written few studies had been conducted in such a way as to enable direct comparisons between different countries, either to establish international differences in innovative performance or to identify differences in regional patterns in different national contexts, particularly between EC and non-EC countries within Europe. In this paper the results of recent surveys of comparable industries in Great Britain and Austria are used to begin to address this issue, with particular attention to some of the inherent difficulties in undertaking such comparisons. By using a mixture of simple cross-tabulations and multivariate logit models, differences between the two countries in the adoption of a number of new process technologies based upon microelectronics in the spheres of manufacturing production, design, and co-ordination are identified. It is suggested that, not only does Austria lag Great Britain in the introduction of new technology, but that variations between similar types of region are more pronounced and entrenched in Austria at that time.

1 Introduction

One of the key features of the current wave of technological change taking place within manufacturing is the adoption of microelectronics-based technologies in traditional manufacturing processes. Such technologies may be roughly defined as comprising all those new technologies which use microprocessors or their electronic equivalents (such as custom or semicustom integrated circuits) either in the form of single integrated circuit devices or in small groups of linked devices. The micro-electronic revolution is not only creating new goods and services, but also altering how they are produced. In manufacturing, microprocessors have gradually penetrated into all aspects of the production process. Applications cover the use of microelectronics-based equipment in design, fabrication, assembly, handling, quality control and testing, or other operations on site necessary to make a product ready for sale. Typical process and production applications include the use of computer-aided design (CAD) equipment, computer-aided manufacturing (CAM) systems, including inter alia computerised numerically controlled (CNC) machine tools, robots, and flexible manufacturing systems (FMS). In contrast to special-purpose automated machines these programmable automation technologies tend to increase flexibility and efficiency (in terms of both the range of products and the volume of a specific product) as well as to increase productivity and control over the manufacturing process (see Fischer 1990).

Over the past ten years a considerable amount of empirical evidence of one sort or another has been amassed that demonstrates that these processes of innovation and technological change are spatially differentiated, both regionally within nations and internationally between nations (for example, Brugger and Stuckey 1987; Jacobsson 1985; Kleine 1982; Nabseth and Ray 1974; Rees et al. 1984; Thwaites et al. 1982; Tödtling 1990). Few studies, however, have been conducted in such a way as to enable direct comparisons between countries, either to establish international differences in the innovative performance of particular industries or to identify differences in regional patterns within different national contexts.

Reliable cross-national comparisons will become an increasingly pressing need as the issue of European integration rises higher on the political and economic agenda. The implementation of the Single European Act in 1993 and the changing climate of East-West relations will add urgency to this issue (Commission of the European Communities 1991; Quévit 1991).

Inconsistencies between national studies in terms of survey design – sectoral composition, choice of innovations, categorisations of variables, and so forth – mean that it is frequently impossible to conclude whether differences (or conversely similarities) between national experiences can be attributed to fundamentally different levels of industrial performance, or different economic, political, and cultural regimes, or whether they are simply the product of different sample designs.

In this paper, evidence from recent surveys of comparable industries in Austria (Fischer and Menschik 1991) and Britain (Alderman et al. 1988; Thwaites et al. 1982) is used to investigate the comparative innovative performance of the two countries in terms of the adoption of some of the key computer-based technologies referred to above. By controlling for variables such as industrial sector, the comparative performance of manufacturing in similar types of region (the core metropolitan region and its immediate hinterland, a traditional iron-based industrial region, and a peripheral region) is identified.

By using appropriate multivariate analyses, the importance of the commonly identified indicators of innovation propensity is tested and the difference between Austrian and British manufacturing establishments identified. The prospects for the different types of regions in the two national settings in terms of the adoption of the components of computerised manufacturing systems are discussed.

2 Methodology

Previous international comparisons have been concerned with the differences between leading industrial nations, such as the USA, West Germany, and the

United Kingdom (for example, Gibbs and Thwaites 1985) or between the core nations of the European Economic Community (EC) (Northcott et al. 1985). Comparisons between other nations within Europe, particularly between EC and non-EC countries, are largely missing. We attempt to fill a gap in this aspect of international comparison by comparing adoption experiences in Great Britain, an EC country, with those of Austria, a non-EC country. It raises the question of whether the types of spatial disparities in technological development observed within core nations are replicated in more peripheral nations and whether they occur with similar levels of intensity.

The research in Austria was undertaken at the Department of Economic Geography of the Vienna University of Economics and Business Administration, funded by the Jubiläumsfonds provided by the Austrian National Bank. Data on the spatial pattern of the adoption of specific techniques within a limited number of manufacturing industries were obtained through interview surveys of senior executives of manufacturing establishments and enterprises. The survey was designed to explore in greater depth the characteristics of adopting and non-adopting establishments, including their approach to technology and investment generally, as well as their reasons for adoption or non-adoption of the specified techniques. In the interviews, we also investigated the sources of information used to evaluate technological change, changes in labour requirements related to technology, and the use of government aid in the adoption process. By use of a questionnaire, we also obtained information concerning the ownership of the establishment, its employment size, the extent of R&D activity, etc.

The data were obtained from establishments in the Austrian metalworking and machinery, electrotechnical and electronic products, textiles and clothing industries. Owing to time and resource constraints, the interviews were limited to four Austrian regions only: the core metropolitan area of Vienna, its immediate hinterland, a traditional iron-based industrial region (Upper Styria) and a peripheral region (Wald-Weinviertel) (see Figure 1) which represent a variety of historic and current economic trends and conditions within the Austrian economy. A total of 185 interviews, each lasting about two hours, were conducted between November 1987 and February 1988 with senior industrialists who were manufacturing in the selected regions (see Fischer and Menschik 1991).

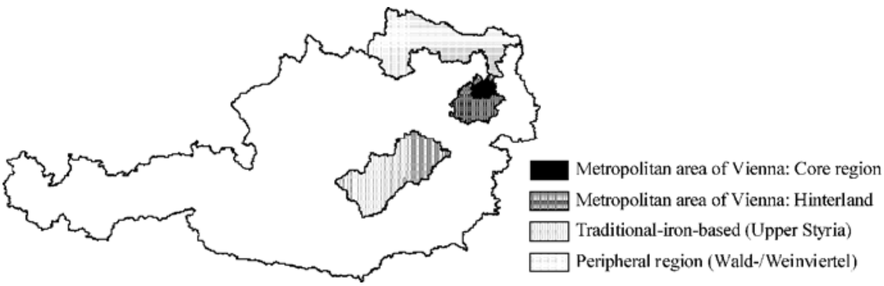

Figure 1 Study areas in Austria

The research in Britain was undertaken by the Centre for Urban and Regional Development Studies at the University of Newcastle upon Tyne and forms part of a long-running research programme into the spatial dimension to technological change. The data presented here were collected in two surveys of establishments in a range of metalworking industries within Great Britain (see Table 1).

The first survey was undertaken in 1981 and formed part of a project funded by the UK Department of Trade and Industry and by the Regional Directorate of the EC (Thwaites et al. 1982). Data collection was primarily by means of a postal questionnaire, but this was supplemented by interviews with executives in 130 establishments in four regions (the South East, West Midlands, the North, and Scotland). The second survey was a follow-up to the first (that is, no new establishments were surveyed) and took place by means of a postal questionnaire in 1986-87, which was followed up by telephone during 1987 and 1988. This latter survey concentrated on identifying adopters of new technologies for the purposes of testing forecasts of technology diffusion at the regional level (see Alderman et al. 1988). As such, this survey was not very detailed, but a final response rate of over 95% of surviving establishments was achieved. In the analysis that follows only those establishments surviving through to 1986 are included.

Table 1 Standard industrial classifications (SICs) for the Austria-Britain comparison

Austria		*Great Britain* (1968 *SIC*)	
SIC	*Description*	*SIC*	*Description*
Metalworking and machinery			
51	Manufacturing of iron and nonferrous metals	331	Agricultural machinery
		332	Metalworking machine tools
52	Machining of metals, steel-girder and light-metal construction	333	Pumps, valves, and compressors
		336	Contractors' plant and machinery
53	Manufacturing of hardware	337	Mechanical handling equipment
54/55	Manufacturing of machines (excluding electric machines)	339	General mechanical engineering
		341	Industrial plant and structural steelwork
58	Manufacturing of means of transportation	390	Engineers' small tools and gauges
Electrotechnical and electronic products			
56/57	Manufacturing of electrical installations	361	Electrical machinery

In recent years manufacturing industry has experienced rapid technological changes which have been focused upon process innovations utilising the advances in microelectronics. In the two studies, we examined the spatial diffusion of selected process innovations which are of particular relevance to the metalworking and machinery industry as well as to the electrotechnical and electronic products industry. The selection of the industries and production techniques for the comparison was an interactive process. The techniques were selected on the basis that they introduced fundamental rather than minor incremental change, were economically significant, and had a comparatively recent diffusion pattern. The selected techniques providing the foci of the comparison are:

- numerically controlled (NC) and CNC machine tools;
- computers for design (CAD) and computer-aided engineering (CAE);
- computers for manufacturing operations (CAM, CAD-CAM) and microprocessors;
- computers for commercial use.

There are some minor differences in technology definition that should be noted. The British follow-up survey was concerned specifically with CAD and drafting systems rather than with computers in the design sphere more generally. Nevertheless, these types of CAD system are the most prevalent and rapidly diffusing applications at the present time.

In the manufacturing sphere the British follow-up survey dropped the broad definition of computers for manufacturing operations on the grounds that this was too vague a definition, concentrating instead on the adoption of microprocessors in the manufacturing process. In other respects the Austrian and British surveys are identical as far as technology definition goes.

2.1 Regional Comparison

The British survey was a national one, in contrast to the Austrian study which was limited to the regions outlined above. It was therefore necessary to identify suitable areas within Great Britain that would provide a reasonable match for comparative purposes. In the event, the choices rested largely on the pragmatic considerations of which areal units were available and the numbers of observations involved (see Figure 2).

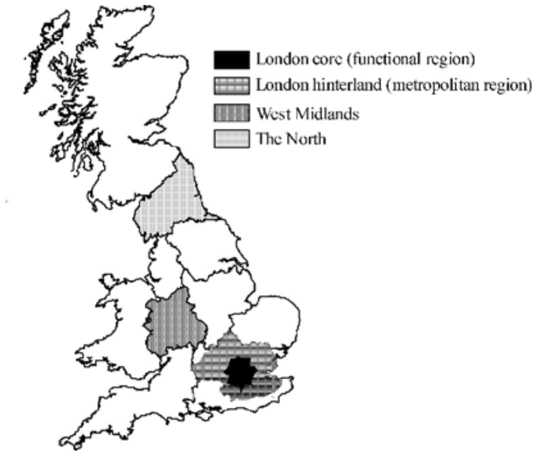

Figure 2 Study areas in Great Britain

The core metropolitan region of Vienna was matched against the London functional region as defined by Coombes et al. (1982), and the hinterland was matched against the rest of the London metropolitan region on the basis of the same regionalisation. As such, the London regions are rather larger than those for Vienna, but this is unavoidable as the equivalent administrative and built-up areas are also considerably larger. These size differences in population terms are illustrated in Table 2.

For the remaining two areas, the West Midlands standard region was matched against Upper Styria as it is the home of the iron-based industries in Britain, and the northern standard region was chosen as a representative peripheral region. The major difference in the case of the North is that most industrial activity is centred on the major conurbations of Tyneside and Teesside, which have no equivalent in Wald-Weinviertel.

Table 2 demonstrates that the British standard regions are rather larger than the Austrian regions. Nevertheless, there are some similarities in that the traditional iron-based regions both have high levels of manufacturing employment (although the same is true of the Vienna hinterland in contrast to that for London). Austrian unemployment in 1981 was much lower than in Britain, although it worsened during the 1980s as in other advanced economies. Moreover, the peripheral region chosen was not experiencing the highest levels of unemployment in Austria the way it was in Britain and the radically different economic problems in these regions, the former figure reflecting a predominantly rural economy, the latter reflecting a predominantly urban problem.

Table 2 Regional comparisons

Area	*Population in* 1981	*Manufacturing employment* 1981 (%)	*Unemployment rate in* 1981
London core	7,665,455	19.6	8.3
Vienna core	1,532,344	27.1	2.1
London hinterland	4,494,072	28.6	5.8
Vienna hinterland	285,936	35.3	2.8
British iron-based region	5,112,349	39.2	11.7
Austrian iron-based region	280,067	34.5	2.9
British peripheral region	3,090,404	30.5	13.3
Austrian peripheral region	278,067	18.4	3.3

2.2 Comparison of the Samples

As a result of the different spatial sampling schemes used it is not surprising to find the composition of the two samples to be different. Table 3 shows that in the Austrian case the sample is dominated by the metropolitan area, whereas in the British case the iron-based and peripheral regions take the ‘lion's share’. The other major distinction, of course, is that the Austrian survey was not large, but extremely detailed, whereas the British survey was large, but limited in terms of the information collected, and this inevitably affected subsequent analysis.

Table 3 Composition of Austrian and British samples (percent of establishments) by regional type. Sources: national surveys (Austria, November 1987; $N = 136$. Great Britain, 1986; $N = 262$) (see Fischer and Menschik 1991; Alderman et al. 1988)

Area	*Percent of establishments*	
	Austria	*Great Britain*
Metropolitan area	63.2	37.4
Core region	36.8	18.7
Hinterland	26.4	18.7
Traditional iron-based industrial region	19.9	34.4
Peripheral region	16.9	28.2

Although an attempt has been made in the two studies to control for sectoral differences (differences in national industrial classifications inevitably cause problems; for example, see Gibbs and Thwaites 1985) by focusing on industries engaged in similar activities (metalworking, electrical equipment, machinery) which may therefore be expected to have broadly similar opportunities and requirements for the adoption of new technology, other factors related to the structure of these industries in the two countries could be influential. One of these factors is the presence in Austria of a strong nationalised sector (the so-called Austrian Industries), which in the industries surveyed accounts for over 10% of employment. Table 4 indicates, however, that in the Austrian case there are rather more independent establishments. Comparing 1981 with 1986 information, the British sample shows a decline in the proportion of independent establishments during the 1980s (and this despite an increasing number of management 'buyouts'). The proportion of branch plants in the British sample was rather higher on the basis of 1981 information.

Table 4 Corporate status composition of Austrian and British samples (sources: see Table 3)

Plant description	*Percent of establishments*		
	Austria	*Great Britain*	
		1986	1981
Single-plant enterprise	50.7	40.1	45.2
Multiplant organisation	49.3	59.9	54.6
Head office	15.4	nd	nd
Divisional headquarter	9.6	nd	24.0
Regional headquarter	10.3	nd	nd
Branch	14.0	nd	30.6

nd no data available

The age structure of the two samples also shows differences, primarily because no establishments starting up after 1981 were identified in the British survey. Table 5 shows how in Austria the age distribution is skewed towards very young establishments, whereas in Britain the skew is towards older establishments.

Table 5 Variation in establishment age by country (sources: see Table 3)

Period of establishment	*Percent of establishments*	
	Austria	*Great Britain*
Pre-1950	21.5	41.3
1950-59	23.0	16.2
1960-69	14.8	25.1
1970-79	8.1	17.4 (1970-79 and 1980 and later combined)
1980 and later	32.6	

The most important distinctions are likely to be in terms of the size distributions, not only because of the theoretical importance of size in technology adoption (for instance, Davies 1979; Freeman 1974), but also because of its observed empirical importance (Alderman et al. 1988; Northcott and Rogers 1984; Rees et al. 1984; Thwaites et al. 1982). Surprisingly, perhaps, the sample-size distributions appear to be similar, but there are more very small establishments in Austria, and more in the 100-499 (number of employees) category within the British sample (Table 6). On this basis alone we should anticipate higher adoption levels in the British context. It is to the national and regional differences in levels of new-technology adoption that we now turn.

Table 6 Differential employment size structures (sources: see Table 3)

Country	*Percent of establishments by employment size*[a]			
	1-49	50-99	100-499	≥ 500
Austria	44.9	18.4	25.0	11.8
Great Britain	38.0	20.2	31.4	10.5

[a] number of employees

3 The Adoption of New Technology

Variations in technological change between countries and regions can be anticipated simply as a result of the differing nature of the enterprises and establishments operating therein (Thwaites 1978). In this section evidence is provided of the extent of adoption of the selected technologies and these are related to the characteristics of the establishments in each country.

In crude terms, we demonstrate in Table 7 that there are substantial differences in adoption levels between the two countries and between the regions within them. In general, with the exception of computers for commercial uses, adoption levels are higher in the British case, although to some extent this is expected, because of the differences in size distribution. However, even in 1981, levels of NC adoption amongst surviving British establishments were considerably higher than they were in Austria in 1987. CAD adoption similarly appears to be further advanced in Britain than in Austria.

Table 7 Adoption of new technology (percent of establishments) by regional type (sources: see Table 3)

Technology	*Metropolitan core*		*Metropolitan hinterland*		*Traditional iron-based industrial*		*Peripheral*	
	Austria	*Britain*	*Austria*	*Britain*	*Austria*	*Britain*	*Austria*	*Britain*
NC machines[a]	14.0	32.7	16.7	38.8	3.7	34.4	17.4	27.0
CNC machines	20.0	49.0	22.2	59.2	40.7	60.0	4.3	44.6
CAD, CAE	14.0	20.4	8.3	38.8	11.1	28.9	8.7	18.1
CAM, CAD–CAM	12.0	nd	5.6	nd	18.5	nd	8.7	nd
Microprocessors	nd	24.5	nd	40.8	nd	41.4	nd	24.3
Computers for commercial use	88.0	77.6	75.0	81.6	74.0	81.1	60.9	75.7

[a] 1981 rate for Britain; nd no data available; NC numerically controlled; CNC computer numerically controlled; CAD computer-aided design; CAE computer-aided engineering; CAM computer-aided manufacturing

Regional discrepancies appear more pronounced in the Austrian case, whereas the British data are notable in that the peripheral North region has similar adoption levels to the metropolitan core; the Austrian periphery would appear to be lagging, particularly in terms of CNC adoption. In Britain it is the industrial heartland of the old iron-based areas and the metropolitan hinterland where technology adoption appears furthest advanced. In both countries the data suggest that for industries such as these the traditional industrial heartland is often a leading area with respect to technology adoption.

The applicability of particular technologies varies between sectors. Alderman et al. (1988) have demonstrated in the British context that, for technologies such as NC and CNC, interindustry diffusion rates vary more than interregional ones. In Table 8 we show that, despite the crude level of sectoral disaggregation employed, differences between the metalworking and machinery sector and the electrotechnical sector are similar in both countries. However, levels of NC and CNC adoption in the Austrian metalworking and machinery sector appear to be relatively lower than in Britain, which may in part reflect the age and size structure of the Austrian sample, but is nevertheless somewhat surprising, given that these are now considered mature technologies (Ray 1984) and it has been argued that CNC in particular is increasingly suited to the operations of the small engineering firm (Dodgson 1985).

Table 8 Adoption rates (percent of establishments) of new technology by industry sector (sources: see Table 3)

Technology	*Metroworking and machinery*		*Electrotechnical and electronic products*	
	Austria	*Britain*	*Austria*	*Britain*
NC machines[a]	11.7	33.7	18.2	27.0
CNC machines	16.5	52.4	39.4	59.5
CAD, CAE	9.7	23.3	15.2	43.2
CAM, CAD-CAM	8.7	nd	18.2	nd
Microprocessors	nd	30.7	nd	48.6
Computers for commercial use	73.8	77.3	87.9	89.2

[a] 1981 rate for Britain, notes see Table 7

The most striking sectoral differences, particularly in the British case, occur with respect to CAD adoption. The electrotechnical sector has found CAD to be particularly relevant in relation to printed-circuit-board design, where computerised methods were first developed in the 1960s (Kaplinsky 1984). Note that in the British case these sectoral differences are only statistically significant in the case of CAD and microprocessor adoption.

It was noted above that the corporate structure of Austrian industry is rather different from that of Britain. Table 9 reveals that technology adoption by corporate status also differs. Headquarters (strictly speaking, establishments with control functions) in the British case appear to have a higher propensity to adopt than their Austrian counterparts. In Britain it is the independent (usually small) establishments that are least likely to adopt new technologies, whereas in Austria the branch-plant sector performs comparatively poorly.

Another factor commonly regarded as important in relation to technology adoption is R&D activity. The precise relationship between R&D and technology adoption has yet to be satisfactorily identified. In relation to product innovation its importance is clear (Thwaites et al. 1981), but in relation to process innovations the effect of R&D is frequently confounded with the effect of establishment size, as larger establishments are more likely to support R&D activities. Of the technologies under consideration here, the one that has the closest a priori link with R&D is CAD, as design activities are an intrinsic part of the R&D process.

By concentrating on the *proportion* of employment within the establishment that is engaged in R&D it is at least partially possible to control for the size effect. Careful inspection of Table 10 reveals the inconclusiveness of any evidence for a clear-cut relationship between technology adoption and R&D, particularly in the case of NC or CNC. Care should be taken in interpreting these figures, however, because there are comparatively few establishments with more than 10% of their employees in R&D. Moreover, the largest establishments are unlikely to have the largest proportional levels of R&D, because the absolute numbers involved would be unrealistic.

Table 9 Adoption rates (percent of establishments) of new technology by corporate status (sources: see Table 3)

Technology	*Single-plant enterprise*		*Multiplant establishment*			
			Headquarter		*Branch*	
	Austria	*Britain*	*Austria*	*Britain*	*Austria*	*Britain*
NC machines[a]	10.1	22.9	16.7	48.1	15.8	35.0
CNC machines	23.2	40.0	25.0	75.9	10.5	55.3
CAD, CAE	7.2	15.2	16.7	50.0	10.5	24.8
CAM, CAD-CAM	8.7	15.2	18.8	nd	0.0	nd
Microprocessors	nd	19.0	nd	59.3	nd	34.0
Computers for commercial use	72.5	63.8	87.5	94.4	68.4	86.4

[a] 1981 rate for Britain, notes see Table 7

Table 10 Adoption of new technology (percent of establishments) related to the percentage of R&D staff in total employment (sources: see Table 3)

Technology	0%		1-4%		5-9%		≥ 10%	
	Austria	*Britain*	*Austria*	*Britain*	*Austria*	*Britain*	*Austria*	*Britain*
NC machines[a]	11.4	19.0	16.4	38.9	16.7	48.1	4.5	18.2
CNC machines	14.3	34.5	20.0	65.1	33.3	51.9	27.3	36.4
CAD, CAE	5.7	15.5	7.3	32.0	20.8	25.9	18.2	45.5
CAM, CAD-CAM	5.7	nd	16.4	nd	4.2	nd	13.6	nd
Microprocessors	nd	15.5	nd	42.1	nd	33.3	nd	54.5
Computers for commercial use	65.7	65.5	90.9	87.3	75.0	74.1	63.6	81.8

[a] 1981 rate for Britain, notes see Table 7

In relation to CAD adoption there is less evidence for a negative trend in adoption as the proportion of R&D staff increases, which is more consistent with expectations. However, there are differences between Britain and Austria in that the major increase in adoption propensity occurs between the 1-4% and 5-9% categories in the Austrian case and between the 0% and 1-4% categories in the British case, indicating that CAD adoption is occurring in establishments with a proportionately lower formal commitment to R&D in Britain than in Austria. Further analysis is required here, because in Table 10 we have not considered informal R&D activities, and a lot depends upon how executives classify R&D staff. CAD systems may be ideal for establishments where there is a lot of routine modification of design and this type of activity may or may not be classed as R&D.

4 Logit Analysis

In the foregoing analysis, we have revealed some consistent patterns of technology adoption between Austria and Great Britain, together with some intriguing contrasts. As noted, however, the differences in the structure of the two samples in terms of size, status, age distribution, and so on limit the extent to which firm conclusions can be drawn. As a first step in overcoming these difficulties, the data were also analysed by means of logit models in order to control for such effects and to identify real differences between the two countries and to establish the extent to which regional variations can be attributed to other factors. Logit modelling is an attempt to overcome the difficulties inherent in bivariate analysis with the rigour of multiple regression modelling for categorical data with a dichotomous response variable (for more details, see Fischer and Nijkamp 1985; Wrigley 1985).

In the simple bivariate analyses reported above no account has been taken of differences in timing and structure of the samples. Before attempting to put the two data sets together it was necessary to remove some of the obvious sources of inconsistency that might otherwise have biased comparative results.

The most serious of these concerns the fact that the British survey was a follow-up survey and that, consequently, no establishments founded after the middle of 1981, the time of the original survey, were included. All British plants are therefore at least six years old (at the time of writing), whereas their Austrian counterparts in some cases are much younger. To overcome this limitation we exclude establishments that started up after 1980. This reduces the size of the Austrian sample to 110 cases.

Definitional differences also mean that some of the technologies referred to above could not be compared analytically. NC was not included in the British 1986 survey on the grounds that it had been largely superseded by CNC and therefore the time periods that are being compared are different. If one bears in mind the aforementioned provisos, three innovations were suitable candidates for analysis: CNC, CAD, and computers for commercial applications. These technologies allow us to examine the three main spheres of manufacturing activity: production, design, and co-ordination, respectively (Kaplinsky 1984).
These make up the three dichotomous dependent variables of the form adopted or not adopted. The restricted nature of the British postal survey again limits the number of independent variables available; however, the following were incorporated into the analysis:

(a) location (peripheral region, metropolitan core, metropolitan hinterland, traditional iron-based region);
(b) establishment employment size (natural logarithm);

(c) corporate status (independent, headquarter, branch);
(d) sector (metalworking and machinery, electrotechnical and electronic products);
(e) age (more than fifteen years old, up to fifteen years old);
(f) degree of product diversification [low, high (more than four major product groups)].

In all of the model results that follow, with the exception of the size variable which is continuous, parameter estimates may be interpreted with respect to the reference category. The reference category is a function of the particular parameterisation used by the estimating package (GLIM) and is set to zero. The reference category consists of independent establishments over fifteen years of age in the metalworking and machinery sector that are located in the peripheral region and have a low level of product diversification.

4.1 Single-Nation Models

The first step in the analysis was to compute separate models for each innovation and each country. Table 11 indicates the degree to which establishment characteristics increase or decrease the probability (strictly the logarithmic odds) of adoption of CNC, CAD, and computers in commercial applications. There is no intention that the results presented in this table should in any sense represent 'optimal' models. Rather, the approach is essentially exploratory and the intention is to demonstrate which variables are important and to identify whether the magnitudes and directions of the relationships are similar or otherwise. Although *t*-values are given as well as the parameter estimates, it should be noted that the most reliable way to evaluate the significance of the estimates is through the change in log-likelihood associated with each parameter. For variables with more than two categories the significance of any one parameter will depend on its relationship to categories other than the reference category which is what the *t*-value reflects.

In the case of CNC adoption, it should be clear from Table 11(*a*) that in Britain the dominant factor is the size variable, and locational effects are not significant. The model simplifies to the size effect, the larger the establishment the higher the probability of adoption, and to a possible age effect whereby younger establishments have a lower probability of adoption. In Austria, by way of contrast, there is a strongly negative branch-plant effect and the electrotechnical sector exhibits a higher level of adoption than the metalworking and machinery sector. There are also strong regional effects reflecting the fact that adoption levels are much higher in all areas compared with the periphery (the reference category), but most notably in the metropolitan hinterland and the traditional iron-based region.

Table 11(*b*), on the other hand, indicates that there is very little variability in CAD adoption in Austria. A very low value of $\bar{\rho}^2$ is accompanied by a predictive success of 90%! This is probably because of low overall levels of adoption of

CAD and may have been exacerbated by the removal of younger plants. Only product diversification is a significant factor here; as one might anticipate, greater diversity increases the probability of CAD adoption. In Britain, size is again an important factor and a significant location effect reveals higher levels of CAD adoption in the metropolitan hinterland than elsewhere.

Table 11 Parameter estimates for the single-nation model (*t*-values in parentheses)

Variable	(*a*) *CNC adoption*		(*b*) *CAD adoption*		(*c*) *Computer adoption*	
	Austria	*Britain*	*Austria*	*Britain*	*Austria*	*Britain*
Headquarter	-1.26 (-1.88)	0.40 (0.84)	0.90 (1.07)	0.41 (0.83)	-1.59 (-1.70)	0.45 (0.63)
Branch plant	-2.54 (-1.99)	-0.07 (-0.21)	0.09 (0.07)	-0.10 (-0.23)	-2.19 (-2.16)	0.58 (1.40)
Size (logarithm of employment)	0.41 (1.85)	0.82 (5.07)	0.02 (0.06)	0.85 (4.72)	1.47 (3.86)	1.39 (5.30)
Electrotechnical sector	1.46 (2.35)	-0.05 (-0.12)	-0.03 (-0.00)	0.69 (1.50)	0.43 (0.41)	0.82 (1.19)
Metropolitan area: Core	2.00 (1.66)	0.32 (0.75)	-0.26 (-0.26)	0.33 (0.63)	1.68 (1.71)	0.21 (0.37)
Metropolitan area: Hinterland	2.80 (2.28)	0.53 (1.19)	0.24 (0.23)	0.99 (1.94)	2.45 (2.20)	0.20 (0.35)
Traditional iron-based region	3.04 (2.40)	0.35 (0.92)	-0.52 (-0.45)	0.38 (0.83)	-0.29 (-0.34)	0.15 (0.30)
High degree of product diversif.	-1.01 (-1.17)	-0.24 (-0.70)	1.47 (1.76)	0.61 (1.43)	1.17 (0.91)	-0.09 (-0.20)
Age less than fifteen years	-0.19 (-0.30)	-0.69 (-1.49)	0.46 (0.60)	-1.10 (-1.62)	-0.17 (-0.22)	1.14 (1.65)
Constant	-4.85 (-3.26)	-3.45 (-4.61)	-3.03 (-2.19)	-5.98 (-6.00)	-4.41 (-2.91)	-4.68 (-4.47)
$\bar{\rho}^2$	0.14	0.14	0.005	0.19	0.35	0.26

Notes see Table 7

Table 11(*c*) indicates that size is more important with respect to computer adoption than to the other technologies in Austria and here the metropolitan regions have significantly higher levels of adoption than the others. (There is also a significant interaction between size and age of establishment, but this is rather difficult to interpret and may be attributable to a few influential observations.) For the British case, size is again the only significant variable and the removal of all others has negligible impact on the goodness of fit.

It is clear then that, for the most part, regional variations in technology adoption are not significant once other factors have been taken into account, with the notable exception of CNC and computers for commercial use in the Austrian case, where the metropolitan and traditional iron-based areas have a higher probability of adoption than the periphery, and in the case of higher levels of CAD adoption in the metropolitan hinterland in Britain. These observations accord with the suggestion that regional variations are likely to be most pronounced when technologies are in their infancy, but that as diffusion proceeds and approaches saturation level regional convergence is likely to be observed (Alderman and Davies 1990).

4.2 Dual-Nation Models

The single-country model provides a test of within-country variations in technology adoption. The dual-nation model allows us to test formally whether or not there are significant differences between Austria and Great Britain in this respect. This involves the addition of a new independent variable taking the value 1 if the establishment is Austrian and the value 2 if it is British. The reference category in these models consists of the Austrian establishments, with all other characteristics the same as for the single-nation model. The new variable appears first in Table 12, which gives the results of the logit analyses for CNC, CAD, and computer adoption. In these models we are interested primarily in interaction effects that will indicate whether or not there are significant differences between the two countries in terms of the factors associated with the adoption of these technologies.

Table 12(*a*) shows that for CNC adoption there is a strong and significant difference in adoption between the two countries with a much higher probability of an establishment having adopted CNC in Britain than in Austria. The regional effects are similar, although the single-nation model indicated these to be stronger in the Austrian case, and the effect of establishment size is consistent between countries. The major difference is in terms of the corporate-status effect, indicated by a significant interaction term for independent establishments in Great Britain.

The results in Table 11(*a*) provide the clue as to how this should be interpreted. The independent plants in Austria are much more innovative than their corporate counterparts seem to be, whereas in Britain there would appear to be little difference, once the effects of factors such as size have been taken into account.

In Table 12(*b*) the results for CAD adoption show that the difference between the two countries is again significant, but less pronounced. However, the analysis confirms that the effect of establishment size is significant in the British case, but not in the Austrian case as the main effect term for the size variable becomes negligible, whereas the interaction term is significant. In both countries the metropolitan hinterland has the highest levels of adoption, but the effect is not significant, because the nature of these locational contrasts is not consistent: in Britain the peripheral area has the lowest probability of adoption, whereas in Austria it is the traditional iron-based region that has the lowest probability. Product diversification does appear to be positively associated with CAD adoption, possibly because greater diversity demands, ceteris paribus, higher levels of design and draughting activity.

Table 12 Parameter estimates for the dual-nation logit analysis (*t*-values in parentheses) [a]

Variable	(*a*) *CNC adoption*		(*b*) *CAD adoption*		(*c*) *Computer adoption*	
	ME	*MI*	*ME*	*MI*	*ME*	*MI*
Great Britain	1.98 (5.24)	3.06 (5.73)	1.27 (2.70)	-2.94 (-2.17)	-0.23 (-0.50)	2.06 (2.63)
Headquarter	-0.10 (-0.27)	-1.36 (-2.52)	0.53 (1.27)	0.50 (1.19)	-0.18 (-0.36)	-1.47 (-2.03)
Branch plant	-2.29 (-0.98)	-1.96 (-2.20)	-0.04 (-0.10)	-0.13 (-0.33)	0.24 (0.66)	-1.43 (1.92)
Size (logarithm of employment)	0.64 (5.36)	0.64 (5.34)	0.58 (4.22)	0.03 (0.14)	1.24 (6.17)	1.64 (6.71)
Electrotechnical sector	0.30 (0.88)	0.42 (1.20)	0.46 (1.24)	0.51 (1.32)	0.44 (0.54)	0.60 (1.09)
Metropolitan area: Core	0.41 (1.12)	0.43 (1.19)	0.12 (0.27)	0.26 (0.85)	0.74 (1.60)	2.35 (3.11)
Metropolitan area: Hinterland	0.82 (2.18)	0.83 (2.14)	0.85 (1.92)	0.87 (1.89)	0.56 (1.17)	2.45 (3.10)
Traditional iron-based region	0.69 (2.08)	0.68 (2.04)	0.25 (0.62)	0.33 (0.79)	-0.07 (-0.17)	-0.06 (-0.15)
High degree of product diversification	-0.46 (-1.52)	-0.46 (-1.51)	0.62 (1.70)	0.84 (2.15)	-0.02 (-0.04)	0.08 (0.18)
Age less than 15 years	-0.24 (-0.68)	-0.32 (-0.88)	-0.37 -(0.79)	-0.45 (-0.95)	-0.09 (-0.22)	3.73 (2.49)
Independent plant in Great Britain		-1.99 (-3.21)		0.80 (3.12)		-1.94 (-2.49)
Metropolitan area plant in Great Britain						-2.35 (-2.98)
Size by plant less than 15 years old						-0.93 (-2.34)
Constant	-4.59 (-6.94)	-3.95 (-5.90)	-5.95 (-6.87)	-3.13 (-2.87)	-3.72 (-5.09)	-5.60 (-5.30)
$\bar{\rho}^2$	0.16	0.18	0.16	0.18	0.24	0.30

[a] *ME* main effects model; *MI* model with interactions, notes see Table 7

Table 12(*c*) reveals that the model for computer adoption is by far the most complex, with three significant interaction terms. Overall levels of adoption are similar between the two countries, but independent plants in Great Britain are less likely to have adopted than their counterparts in Austria. Regionally, establishments located in either the metropolitan hinterland or the core in Austria are proportionately more likely to have adopted computers for commercial applications than in the equivalent areas in Britain. Young establishments also appear to be more innovative, but the interaction term between size and age indicates that this is less true the larger the plant. This interaction was only observed in the Austrian data and does not appear particularly meaningful. It is possible that the age effect is too crudely defined and should ideally be treated as a continuous variable. Moreover, by definition, all establishments are at least six years old in these models.

By and large, sectoral differences in this dual-nation model are not significant, although the electrotechnical sector is more innovative in terms of CNC adoption in Austria than the metalworking and machinery sector. The sectoral breakdown used here is very crude, however, and the problems associated with matching sectoral classifications were referred to earlier.

5 Constraints on Adoption

The evidence presented here would seem to provide some fairly conclusive evidence that the adoption of new technology in Austrian firms is some way behind that in Britain, notwithstanding the differences in the characteristics of manufacturing industry between the two countries. Identification of the constraints on adoption is obviously an important objective, both from the perspective of individual companies and from a policy point of view.

Some further evidence from the two surveys sheds some light on the major constraints to adoption as expressed by industry executives. In the Austrian case the problems of lack of finance and a lack of suitably qualified staff topped the list (about 36% of establishments). In over 95% of cases, manufacturers called upon internal funds. Bank finance and government assistance was used by a third of respondents only. Comparable figures for the British case are not easily extracted, but corporate establishments relied very heavily on internal or company group funds to support technology adoption, whereas for independent establishments bank finance was more important (Thwaites et al. 1982).

In Britain the dominant constraint appears to be less the lack of finance per se, than the inability to justify the investment. A major constraint on investment in new technology for branch plants in particular is the requirement to demonstrate a very rapid payback (Alderman and Thwaites 1987) and this becomes increasingly difficult the more sophisticated the technology. This is one obvious reason for the slow rate of uptake of new forms of manufacturing technology, such as flexible manufacturing systems (FMS), which remain the preserve of the larger establishments and enterprises (see Bessant and Hayward 1986).

In 1981 the British survey found the lack of suitably qualified staff to be a comparatively minor problem, although this may well be changing, particularly with serious shortfalls foreseen in the information-technology field. Other evidence suggests that it is less likely to be the adoption of technology that is constrained than the successful implementation and operation of the technology once it has been adopted (Alderman and Thwaites 1987).

In the Austrian case the most important sources of information concerning innovation activities were trade journals, sales literature, and exhibitions. Although these were also revealed to be important sources in the British survey, manufacturers' demonstrations and visits by suppliers were considerably more so. It is possible that this is a reflection of the different sizes of domestic market.

Britain is likely to have more equipment manufacturers and suppliers than Austria and a greater reliance by Austria on imports may account for a higher use of exhibitions as important information sources. It is interesting in this context that ÖIAG is currently undergoing a major restructuring, in which it is aimed to secure jobs partly through increasing R&D efforts and gaining access to foreign technologies and products, and this will entail closer links between Austria and the EC.

6 Conclusions

In this paper, we have reported results of an attempt to compare regional and national innovation activity in the Austrian and British contexts, with the use of survey data obtained from a broadly similar group of manufacturing industries. We have demonstrated that significant differences in the structure of industry in the two countries make comparison an extremely difficult exercise. Some initial attempts at controlling for differences in establishment characteristics between the two countries were made through the use of logit analysis.

The results achieved thus far seem to suggest that the Austrian metalworking and machinery sector and the electrotechnical sector, are lagging behind their counterparts in Great Britain in the adoption of manufacturing process technologies, although the use of computers in the commercial sphere is as advanced as in Britain, if not more so. To a large degree these findings arise as a consequence of a younger age and smaller size structure of establishments within the Austrian sample and it is not surprising to discover that the major constraints on adoption in the Austrian sample were lack of finance and lack of suitably qualified staff, which are both typical problems for young, small establishments.

The results of the logit analysis reveal that variations between the four regional types in Britain, to the extent that they exist at all, are largely attributable to different structural characteristics, such as size, ownership, sectoral composition, and so on. Indeed, in the British case establishment size is the dominant factor associated with technology adoption and the only consistently significant one. In Austria regional differences still remain after controlling for these factors, suggesting more deep-seated problems with respect to technology adoption for the peripheral areas. Adoption in Britain has probably proceeded sufficiently far that we are now observing regional convergence in adoption levels.

An intriguing question arises from the finding that the independent establishments in Austria appear to be relatively more innovative than those which are part of larger enterprises, which is in contrasts to the experience in Britain. To the extent that Austria experiences problems of a lack of innovativeness in terms of new manufacturing-process technology it appears to have more to do with larger enterprises and the poor performance of branch plants than it does with the difficulties usually experienced by small independent firms.

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