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**Digital Information Network Technologies,  
Organizational Performance and Productivity**

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# **Digital Information Network Technologies, Organisational Performance and Productivity**

## **An Exploratory Study of the Public Sector in Europe**

By

**Alexandre Caldas, Paul A. David and Orges Ormanidhi**

***The Oxford Internet Institute***

20 December 2005

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## EXECUTIVE SUMMARY

### The study and its organisation

The changing extent of adoption and the modes of utilising networked informational technologies within the public sectors of modern economies, and the ways in which these developments affect the performance of public organisations are matters of obvious importance from the economic standpoint, as well as for the political and social consequences that may follow. Yet, the economic aspects of the uptake and utilisation of digital network technologies by organisations, and the effects these have had upon both their internal operations, and their interactions with citizens and private sector organisations, have begun to be studied only recently. A significant advance in systematic quantitative research on this subject has become possible recently, due to the availability of a remarkable dataset. That material was gathered in a survey of more than a thousand public sector organisations located in eight European countries, which was conducted during 2003 by the Momentum Research Group for the *Net Impact 2004* report sponsored by the Cisco Corporation.

This Report presents selected results from the Oxford Internet Institute's exploratory study of this remarkably body of data. The research and its findings in this phase focused on three distinct but interrelated sets of empirical phenomena:

(1) ***Aggregate diffusion patterns and trends***: The macro-level extent of e-network technology adoption in the public sector as of the beginning of 2004, and the projected near-term and planned adoption rates, across the region represented by the seven western European countries and Poland from which survey data was gathered.

(2) ***Technology acquisition and deployment by individual organisations***: The main patterns in the adoption of specific e-network technologies by individual organisations, and the resulting overall "profiles" that can be identified as characteristic of distinct stages of advance in the acquisition and deployment of digital information network technologies (DINT) by each of the different types of (government and health) organisations in the public sector.

(3) ***Performance "impacts"***: The relationship between micro-level estimates of changes occurring in selected aspects of organisational performance (with respect to "productivity" and customer/client satisfaction) that were gathered from a sub-sample of the survey population, on the one hand, and, on the other hand, the status of the organisations' respective DINT facilities of the reporting organisations and the particular business practices they were following in utilizing their network infrastructures and networked applications.

The organisation of this presentation is straightforward. Issues motivating our study of each of the foregoing topics, and the connections among them, are discussed in Part I. Part II takes up the questions of diffusion at both the macro- and micro-levels. Part III tackles the third topic, presenting the findings of a preliminary approach to quantifying the differential “impacts” on organisational performance that are associated with differences in the configuration of e-network technologies and accompanying business practices. The text concludes with a number of necessary qualifications that point to both the need for caution in interpreting the findings we present, and the yet unexhausted potentialities for further, more refined analysis of the existing data and supplementary material that may be gathered in future surveys. In the interest of conciseness, and to avoid unduly burdening readers with technicalities, discussions of the underlying survey data, methodological problems, statistical procedures, and selected details of the results have been placed in addenda for each of the three Parts which are grouped following the text.

## **Key findings on the extent and pattern of technology diffusion**

### ***At the macro-level: the public sector in Europe in 2003 and after***

Estimates of the macro-level extent of adoption of the main classes of network services and networked applications by public organisations across the 8 European countries covered by the NI 2004 survey point to the existence of something resembling a “digital divide”. Quite large proportions among these “connected” organisations (well above two-thirds) had equipped themselves with these technologies at basic levels, such as network virus detection, security and recovery services, and back-office organisational control applications (for financial accounting and human resources management). A much smaller faction among these organisations had rolled out more sophisticated network infrastructures and provided their employees with access to web portals and customer/client relations management systems – thereby supporting more than basic business functions.

The larger organisations -- particularly those having 500 or more employees and the national government organisations in the northern European region -- generally have been fastest off the mark in introducing the more advanced technologies and deploying them more extensively. The projections we have been able to make of future trends in technology adoption on the basis of survey responses, however, suggest that the presently existing “divide” is not likely to persist long into the future. Rather, it appears to be a transient result of lags in the inter-organisational diffusion of these e-network technologies associated with differences in region, size and type. The substantial convergence that is observed in adoption plans for the entire array of services and applications points to a relative fast phase of “catch-up” by the laggards in the near-term – which we envisage as occurring during the 2003-2008 interval.

### ***At the micro-level: technology profiles of the organisations***

More detailed examination of patterns of technology adoption at the micro-level lends further support to the impressions gained from the macro-level data. By applying the statistical technique of cluster analysis to the full set of observations in the TDM survey on network services, networked applications and the extent of intra-organisation deployment of those applications, it is possible to distinguish a small number of technology-adoption configurations (clusters) in each of those three dimensions. The clusters in each dimension can be ranked in ascending order from a “basic profile” to more extensive and sophisticated technology profiles. Examination of the cross-section distribution of organisations among the profiles thus defined reinforces the two suppositions drawn from the macro-level indicators. The first is that public sector organisations in Europe have tended to follow similar dynamic paths of technology acquisition and deployment, and the second is that those who have been slower to start on this ascent will be catching up with the leaders before very long.

### ***The distribution of organisations by level of “technology profile”***

An overall profile, combining the indicators of the relative technological positions of individual organisations in the three separate dimensions just noted has been constructed by performing a “meta-cluster” analysis. This procedure assigns each organisation to one or another of a distinct number of “technology profiles” that are associated with the constituent “cluster-assignments” and two other (binary) classifications. The latter capture distinguishing features of their network infrastructures and of the range of business functions that are supported by their networked applications. This method of “data reduction” yields meta-clusters that have a rank-order, and it reveals that the large organisations are systematically under-represented among those observed at the lowest level of these summary technology profiles. While this suggests that organisation size may well be correlated with access to budgetary and technical resources that have advantageously affected the advance on the part of the large organisations, organisation size *per se* may be not exercising independent effects upon the rates at which these organisations are able to improve their performance.

The meta-cluster analysis of the patterns of technology acquisition and deployment reveals that there are differences among the various types of organisations in their distributions among the levels of the ascending scale of technology profiles that we have identified. This is seen clearly from the variation in the locus of relative concentration across the array of organisation types. Whereas regional government organisations are significantly concentrated at the lowest level, and local clinics and health care organisations tend to be clumped together at the level just above that, national government organisations and other entities in the health sector (particularly those dealing with health insurance) are disproportionately concentrated at the highest level of our technology profiles. Hospital and laboratories, clinics and other units of

the government sector occupy intermediate positions among which the differences in the rank ordering technology profiles is not clear-cut. Whether the future will witness a tendency toward technological convergence by the different public organisations at the upper end of the scale remains an open question. Their distinctive range of functions makes it more likely that the substantial differences now present will persist for some time to come.

### **The pace of technology diffusion and aggregate productivity growth in public sector organisations**

The projected macro-level trends in the adoption of these e-network technologies carry some implications as to the likely growth of average productivity among employees in public sector organisations. To bring these out, the quantitative trends in the sector-wide extent of diffusion can be considered in conjunction with the what has been learned (in Part III of the Report) from analysis for a sub-sample of these organisation of the relationship between their adoption and mode of utilisation of e-network technologies, on the one hand, and, on the other hand, the proportionate rates of improvement that their business managers' perceived had occurred in the average number of cases resolved per employee. By combining the two types of empirical information within a formal (mathematical) model one can obtain approximate estimates of the implied rate of growth in the sector-wide average number of "cases resolved per employee" during the period 2003-2008.

Our estimates of the aggregate annual growth rates obtained for this generic "task productivity" measure span in the range between 2.2 percentage points and 5.6 percentage points. The lower rate refers to the direct effects of the projected diffusion of digital information technologies whose adoption was associated with increases in average labour productivity at the organisation level; the higher of the pair of growth rates reflects the inclusion of an estimate of indirect "learning effects" and network externality spillovers associated with the accumulation of experience in the use of those technologies.

Rather strikingly, the foregoing magnitudes closely resemble the pace of advances of aggregate labour productivity in the U.S. private domestic economy during the period beginning in the late 1990's. This era has seen a very substantial resurgence of the rate of growth of labour productivity, a development that has been attributed by macroeconomists to the cumulative effects of ICT-embodied capital formation, worker retraining, and the associated reorganisation of production and distribution operations within the U.S. private domestic business economy. Although the broadly parallel results presented here for the European public sector are indirect forecasts based upon a narrow indicator of task productivity, they lend a plausible degree of concreteness to the view that industrially advanced economies during the years ahead will see a similar surge of improvement in at least some dimensions of public sector organisations' "productivity performance."

## Key findings about e-network technology impacts on selected aspects of organisational performance

Four salient findings emerged from our investigation of the factors that appear to systematically affect the organisational performance gains in Europe's public sector organisations. These relate to the differential impacts upon productivity improvements and increased client and customer satisfaction that are associated with differences among organisations in the following respects: (1) their networked technology "profiles," (2) their adoption of "best practices" in deployment and utilisation of the new technologies, (3) their use of particular combinations of technology and "best practice" approaches in implementation and application, and (4) national differences vs. differences between government and health-sector organisations.

1) The main significant difference is that between the marked of performance improvements perceived by managers in organisations that had attained a minimal overall technology profile and the *smaller* proportionate gains reported by organisations that were considerably more advanced in their acquisition of e-network technologies. The "minimal" or basic technology profiles simply affords clients and customers online access, provides employees with virus-free email, and networks the organisation's on-line back-office applications for managing accounting and finance, and human resources management and training. By contrast, the technologically "more advanced organisations" in this comparison were those that had gone beyond the "basic profile" by adding internal and external web portals and moved toward having the complete array of networked applications.

1a) The pattern of associated performance payoffs in the reported rates of increase in average cases resolved per employee, and in measures of customer and citizen satisfaction, is consistent with the existence of rapidly diminishing marginal payoffs to further technology acquisition without accompanying organisational changes. The former group of organisations may well have experienced (and therefore report) bigger percentage gains during the preceding year than was the case among their counterparts whose technology profiles had advanced beyond that basic level during the same time interval. But, because the available data are cross-section observations of percentage changes in performance metrics, rather than time-series data for the organisations in question, the "diminishing marginal returns" interpretation is merely an inference.

1b) A second, rather different interpretation can be given to the foregoing findings. Business decision managers in organisations that are still at low levels in terms of their digital networked technology adoption/deployment may tend to over-estimate the pure, technology-driven effects on performance of having become "Internet-connected" at that basic level. The first stage of the transition to complete network connectivity could well be accompanied by strong performance improvements arising from



induced changes in employee motivation and morale that are associated with the introduction of new equipment, altered working conditions, and greater managerial attention. Effects of that kind – so-called “Hawthorne effects” – are found to be strongest during the initial introduction phase of improvements in working facilities and altered routines; and Hawthorne effects on worker productivity in industrial establishments typically are observed to wear off with the passage of time, unless renewed by recurring major changes accompanied by continued managerial and supervisory interest and attention.

1c) Of course, it also remains possible that the business decision managers in organisations that are still at very early stages in their use of network services and networked applications may have been particularly concerned to encourage the allocation of resources that would enable continuation of the process. That might have led them to be particularly disposed to offer overly enthusiastic estimates of the performance gains that accompanied the initial steps.

2) Some among the purported “best practices” in the implementation of digital network technologies are found to matter quite a lot, but most of the items in the long list of such business process practices and features of organisation culture affecting IT that were examined in the context of our statistical framework do not significantly affect the estimated rates of performance improvement. In our final results, only 2 of the 13 supposedly significant “best practices” that the *NI 2004 Report* cited in the case of customer and citizen satisfaction remained as having a statistically significant positive effect on improvements reported by organisations that tracked the metric in question. These two were “integration of business processes” and whether a “strategic IT plan was communicated throughout the organisation.” There is some evidence that a third, closely related practice also contributes to boosting performance: the existence of network wide applications that support data-mining and analysis.

2a) In the case of the conventional productivity improvement metric (based on cases resolved per employee), none of the supposed “best practices” had statistically significant impacts when allowance was made for the effects of differences between government and health organisations and national differences. Only the “integration of business processes” was found to contribute significantly to shortening the average case resolution time. Thus, it appears that it is the latter practice – entailing the consistent alignment of business processes with networked applications and the organisation’s network infrastructure -- that appears to be the most robustly pervasive, and hence reliably “best” in its positive association with increased performance with regard to productivity and customer and client satisfaction.

3) The results of our regression analysis studies clearly indicate the existence of generally higher payoffs – in terms of rates of performance improvement -- where public sector organisations at higher technology profile levels also adopt key “best practices” in technology application. The markedly greater

magnitudes of the resulting impact effects on the productivity metrics are quite striking, especially in comparison with the average performance improvements described by the *NI 2004 Report*

3a) Whereas the *NI 2004 Report* found estimated impacts in the 20-45% range for improvements in average time to case resolution where “best business process practices” were followed, same range of impacts appear from our analysis to be obtained *when none of the so-called “best practices” in business process and organisation management are present*. Moreover, where there is “integration of the business process” with network services and applications, the range of impacts is seen to be raised by a factor of more than three-quarters.

3b) Still more impressive results emerge in regard to the estimated impacts on average number of cases resolved per employee, the most reliable of the pair of productivity metrics we studied. Organisations that had deployed internal and external web portals among their network services, were providing more than the minimum profile of networked applications (finance and accounting, and human resource management and training), and had also attained an above-median extent of deployment of customer or citizen relationship management applications on their network, appear to benefit greatly when they consistently align these technologies with their business processes. The addition of just that form of “best practice” alone is associated with a more than four-fold increase in the annual percentage growth rate in cases resolved per employee. This is found to be the case across the entire range of organisational types and countries when explicit allowance was made for such variations.

3c) Thus, it appears justified to surmise that if there is an incipient tendency towards diminishing marginal returns to technology acquisition investments alone, it can be more than overcome by commitment to consistent integration of business processes in these public sector organisations.

4) Inter-country variations in manager’s estimates of performance payoffs from ICT investments generally are not found to be statistically significant *where any of the other explanatory factors are present*.

4a) Despite the emphasis placed on national differences by the presentation of finding in the *NI 2004 Report*, our results do not show many significant inter-country differences in changes in the average number of cases resolved per employee. In the case of changes in customer and citizen satisfaction, we have found that the average rates of performance improvement are markedly lower among both government and health sector organisations in Germany. Similarly, the impacts on the average speed of case resolution in both Germany and Sweden exhibit significantly smaller improvement percentages than the groups including the U.K., Italy, Holland and France.

4b) The findings just noticed, however, may reflect the existence of certain systematic inter-country differences in the configurations of networked information technologies that are distinctive among public organisations in the generally more advanced northern European region, but is not adequately captured by our simple cluster analysis approach to characterizing “technology profiles.” It thus remains a possibility that because the nationality effects are capturing differences that would be identified by more sophisticated controls for technology deployment profiles, the results give the appearance of a tendency towards smaller incremental improvement of organisational performance in the countries that were farthest advanced in integrating their business processes with a full array of e-network technologies.

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### PART I

#### MOTIVATION, DATA CHALLENGES, AND OPPORTUNITIES

The subject of this exploratory study is the conditions surrounding the adoption and deployment of digital information network technologies (DINT) among organisations comprising the public sector of a number of European economies, and the implications these have for organisational performance. To have a sustained impact upon economic performance and economic welfare, it is obvious that new technologies must be adopted. The effects of technological innovations on the measured productivity of economic activities will depend upon the manner of their adoption, which is to say, upon the way they are deployed and the accompanying organisational adjustments and investments made in complementary inputs of resources. No less obviously, the changing extent of adoption or “diffusion” of a technology must affect the magnitude of its impacts upon productivity levels.

Thus, the sets of conditions that underlie the dynamics of diffusion and the mode of implementation have a powerful role in shaping the effects of technological and organisational innovations. These effects impinge not only on the costs of production of business and not-for-profit entities, but on the economic welfare of customers and clients who receive the goods and services that can be produced and delivered by these technological means. This applies no less for entities in the public sector that provide services to households and firms than it does to the private business sector of the economy, but, in the case of governmental and public health services there are aspects of organisational “performance” that also can affect welfare indirectly through the workings of political processes, and the well-being of the population.

#### **Too important a subject to be so little studied**

During the past two decades a great deal of attention has been directed to questions concerning the social and economic impacts of the broad category of information and communication technology innovations.<sup>1</sup> Most of the

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<sup>1</sup> Much of the resulting quantitative literature has dealt with the information technology-productivity growth nexus at the macroeconomic level, and the greater part of it has focused on the U.S. experience. See D. W. Jorgenson, M. S. Ho, and K. J. Stiroh, *Productivity, Volume 3: Information*

systematic quantitative research by economists on this theme has been focused on the issue of how the productivity and profitability of business organisations has been affected by "IT investments" in the form of computer and computer-mediated telecommunications hardware and software. But such investigations are only beginning to be extended to encompass the newer category of digital information network technology investments -- to which we have here given the acronym DINT, and will refer to, alternatively, as "e-network technologies".

Furthermore, although there is a long tradition of social science and management science research into computer procurement and utilisation by civilian agencies of government (not to mention defence agencies), growth-accounting analyses of IT effects on productivity remain confined to the private domestic economy and its sectors, and econometric analysis of micro-level data, similarly, is focused on business firms.<sup>2</sup> As far as the public sector is concerned, therefore, the upshot is that virtually no attention has been devoted to systematic investigation of either the overall extent of the diffusion of network infrastructure services and networked applications; nor to the detailed patterns of adoption within the broad category of e-network technology; nor to the accompanying changes taking place among the variety of "non-business" organisations of the modern economies – let alone the developing world.

Yet, civilian branches and agencies of government and other non-profit organisations provide a wide array of critical services to citizens and businesses. Collectively their operations employ a large portion of the domestic productive resources of their respective societies. They are substantial purchasers of capital equipment -- including durable equipment embodying new technologies, including digital information network technologies. The present state of incomplete knowledge regarding the specifics of their e-network technology use is therefore unsatisfactory, and rather surprising in view of our general appreciation that the technologies deployed by any organisation shapes the kinds of goods and services it can deliver, the size and skills of the workforce it must employ, and both the location and characteristics of the physical facilities it requires.

Beyond the lack of quantitative measures at the aggregate level for IT capital formation in the public sector, the picture of the current pattern of the diffusion of e-networked (DINT) systems into use remains sketchy at best. There is an extensive literature, dating from the pioneering research of political scientist in the 1970s, which documented and analysed organisational factors in the gradual diffusion of mainframe and then mini-computers in civilian

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*Technology and the American Growth Resurgence*, Cambridge, MA.: MIT Press, 2005, for an overview and synthesis of the literature and presentation of the authors' important contributions.

<sup>2</sup> This coverage, and the implied lack of quantitative research on the ICT-productivity nexus in the public sector is exhibited by a recent, otherwise comprehensive collection of informative studies focussing on aggregate and industry and firm-level productivity in the Netherlands: George Gelauff et al., eds., *Fostering Productivity: Patterns, Determinants and Policy Implications*, Amsterdam, London and New York: Elsevier, 2004.

government.<sup>3</sup> Economists subsequently have utilised the available statistical records relating to federal government computer acquisition in econometric studies of the effects of procurement policies, network effects on switching costs on adoption choices, standardization and much else besides.<sup>4</sup>

By contrast, quantitative research establishing the changing extent of internet connectivity and network access to computer applications within public sector organisations is still in its infancy. Comparatively little is known about the degree to which this component of public capital formation has been concentrated within particular organisations of the civilian branches of governments, rather than being more widely distributed among them. The same can be said with regard to our knowledge of how extensively, or narrowly new information technologies are deployed within individual organisations, rather than being made available only to a small and select part of their workforce.

The persistence of such a dearth of information about the extent of inter-organisational and intra-organisational diffusion of IT within the public sector is all the more remarkable when one considers that it is now understood that both the extent and the pace of technology diffusion affect the realised rate of growth of aggregate labour productivity, and measures of overall input (multifactor) productivity. The latter relationships are well documented by research on the private domestic business sector and in its individual industrial branches in a number of economies. Further, inasmuch as the connection between the dynamics of technology diffusion and macro-level productivity improvement is in principle equally applicable to measurable aspects of the performance of the public sector and its branches, this constitutes provides one important source of motivation for the present effort to illuminate the current state of IT (and DINT) adoption there.

The burden of much of the micro-level empirical research carried out by economists on the productivity impacts of IT investment in the private sector is that installing hardware and software systems is not sufficient to significantly raise organisational productivity.<sup>5</sup> Other, complementary investments are

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<sup>3</sup> See, particularly, K. Kraemer, W. H. Dutton, and A. Northrop, *The Management of Information Systems*, New York: Columbia University Press, 1981; J. L. King and K. Kraemer, *The Dynamics of Computing*, New York: Columbia University Press, 1985; K. Kraemer and J. L. King, "Computing and Public Organisations," *Public Administration Review*, 46, 1986: pp. 488-96. These important studies sought to explain why the diffusion of computer-based information systems was proceeding relatively slowly at all levels of government in the U.S., in comparison with contemporaneous developments in the business sector.

<sup>4</sup> See, e.g., S. M. Greenstein, "Did Installed Base Give an Incumbent any (Measurable) Advantages in Federal Computer Procurement?," *Rand Journal of Economics*, 24(1), Spring, 1993: pp. 19-39; S. M. Greenstein, "Sole-Sourcing versus Competitive Bidding: U.S. Government Agencies' Procedural Choices for Mainframe Computer Procurement." *Journal of Industrial Economics*, XLIII (2), June, 1995: pp. 125-140; S. M. Greenstein, "Lock-in and the Costs of Switching Mainframe Computer Vendors in the US Federal Government in the 1970s," *IEEE Annals of the History of Computing*, 17(3), Winter, 1995: pp 58-66.

<sup>5</sup> See, e.g., Erik Brynjolfsson, Lorin M. Hitt, and Shinkyu Yang, "Intangible Assets: Computers and Organisational Capital," *Brookings Papers on Economic Activity: Macroeconomics* (1), 2002:

required -- in redesigning organisational business processes, restructuring employee responsibilities and tasks, retraining and altered recruitment criteria, and, in some cases, redefinition of the nature of the goods and services offered to customers and clients.<sup>6</sup> Does this apply equally to all organisations that make use of IT? In particular, does this conclusion hold also for organisations in the public sector of the economy that are engaged in providing services to individual private citizens and clients in other organisations, whether within the business sphere or in government? A generalized "organisational perspective" is embraced by Darrell West in his recent study of E-government performance based on an extensive survey and analysis of the content of government agency websites in the U.S. and seventeen other countries:<sup>7</sup>

"An organisational approach posits that the pace and breadth of change is affected by factors such as the nature of work routines within bureaucratic agencies and the degree to which the organisation is open to change. These factors have enormous consequences for the speed of diffusion of technology, people's receptivity to using new technology, and the extent to which inventions transform society and politics."

As plausible, indeed compelling as the logic of this position may be, it does not substitute for actual empirical examination of the interplay between external and internal organisational conditions that affect the pace of adoption, and the manner in which networked information technologies are implemented in government organisations of diverse kinds. Neither does it warrant casually extrapolating to the public sector the conclusions that have been reached about the impacts of ICT and related investments on the performance of business

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pp.137-199; Erik Brynjolfsson, and Lorin Hitt, "Computing Productivity: Firm-level Evidence," *Review of Economics and Statistics*, (June) 2003; Timothy F. Bresnahan, Erik Brynjolfsson, and Lorin Hitt, "Information Technology, Workplace Organisation, and the Demand for Skilled Labour: Firm-Level Evidence". *Quarterly Journal of Economics*, Vol. 117 (February), 2003: pp. 339-376.

<sup>6</sup> Representative of this view are the following statements by Erik Brynjolfsson ("The IT Productivity Gap", in *Optimize* magazine, July 2003, Issue 21): "IT is only the tip of a much larger iceberg of complementary investments that are the real drivers of productivity growth. In fact, our research found that for every dollar of IT hardware capital that a company owns, there are up to \$9 of IT-related intangible assets, such as human capital—the capitalized value of training—and organisational capital—the capitalized value of investments in new business-process and other organisational practices. Not only do companies spend far more on these investments than on computers themselves, but investors also attach a larger value to them....For instance, at Cisco Systems, we observed an emerging "Internet culture" of distributed information flow, worker empowerment, and ubiquitous access to Web-based data for employees, suppliers, and customers. At United Parcel Service of America, we saw the importance of end-to-end integration of systems and a focus on execution. At Dell Computer, we witnessed the transformation of the factory floor using new production-planning systems and a dramatic reduction in work-in-process inventories.

<sup>7</sup> Darrell M. West, *Digital Government: Technology and Public Sector Performance*, Princeton: Princeton University Press, 2005, p. 12. On the generalized organisational framework and its application to public sector adoption and use of technology, see B. Bozeman, *All Organisations are Public: Bridging the Gap Between Public and Private Organisational Theories*, San Francisco: Jossey-Bass, 1987; H. Margetts, *Information Technology in Central Government*, London: Routledge, 1999.

organisations. The problem is that the conceptual gap between public and private organisations is much more readily bridged than the gaps that appear when one undertakes to implement the common theoretical framework for purposes of quantitative analysis.

For one thing, much of the focus of economic research into the “performance impacts” of information technology has been concerned with issues of productivity improvement, for which purposes it is essential to begin with some reasonably well-defined measures of organisational “production,” or, alternatively, of average “costs per unit of output.”<sup>8</sup> Such metrics may be found for specific aspects of the activities carried on by public agencies, just as is the case for business entities, but it is obvious that in this sphere there is no simple “bottom line” analogous to profits; nor can the would-be quantitative analyst look to the market – as is done when studying firms – to provide relative prices that allow aggregation of the multiplicity of otherwise incommensurable goods and services into indices of “organisational output” which can be compared with the organisation’s inputs of resources. It is, therefore, quite understandable that economists engaged in “productivity research” at both the macro-level and the micro-levels have been hesitant in pursuing their subject into the public sector and its constituent organisations.

### **Data Challenges and Opportunities**

One of the very few attempts to delve into this area is the recent report from the Momentum Research Group, prepared for Cisco Systems: *Net Impact 2004: From Connectivity to Productivity*. Rather strikingly, the summary “key finding” from this path-breaking study of a large sample of European public sector organisations presents a conclusion that is very much in line with widely held views about the impact of ICT investment in large business firms:

“A balanced approach to network investments, process reengineering, and enterprise application adoption results in greater functional-level business outcomes.” (p.9)

Although this assertion about public organisations seems quite reasonable, especially in its conformity with widely accepted views formed by studies of the information technology – productivity nexus in large business organisations, the empirical grounds upon which it presently rests may not be as firm as they appear. What is meant by “a balanced approach” seems to be clear enough: the concurrent adoption of sophisticated network infrastructures aligned with “investments in networked applications,” and “integrated business processes.” But the existence of an association between specifics of those organisational practices that are required for alignment and integration, on the

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<sup>8</sup> In general the measurement of real gross output (requiring price deflation of current revenue from shipments) is regarded as more firmly grounded in manufacturing industries than in the service sector of the private economy, precisely because the per unit flow of services remains ill-defined. Consequently, it should be appreciated that the distinctive problems of productivity measurement encountered in the case of public sector activities, which largely involve service provision, stem from the absence of market determined revenues and prices.



one hand, and objective “productivity gains”, on the other hand, even if it is statistically significant, may be a correlation arising from other conditions and characteristics and so, in itself, does not establish the existence of a causal connection. That is a generic problem with which statistical analysts must wrestle, and about which those who depend on their interpretive conclusions should be cautiously aware. It is one that applies with equal force to the findings reported here.

In the specific context of the Momentum Group’s study, there is a further and less complicated issue, but one that may be just as serious: the available measures of the induced changes in “functional-level business outcomes” are subjective estimates that are not necessarily related to *objective* indicators. Although subjective assessments of such impacts have been gathered from the responsible business decision managers (BDMs) in a sub-sample of the organisations whose network technologies were being “tracked” (i.e., monitored), the perceptions they reported did not necessarily refer to the reality of objective experience of their own organisations. What we have to work with are managers’ responses to requests of their “estimates” of the percentage changes that occurred over the past year in various measures of organisational performance -- whether or not their perceptions were informed by quantitative indicators that their organisation had tracked during the period in question. Considerable ambiguity therefore surrounds both the precise details of the association between “perceived impacts” and “tracked and measured impacts”; and between the managers’ “perceived impacts” and the actual experience of their organisation in adopting and implementing specific e-network technologies.<sup>9</sup>

The foregoing are not the only significant lacunae in our understanding of the IT-productivity nexus in the public sector -- nor, indeed, of related questions that affect the performance of business organisations. For the most part, systematic productivity studies of this kind have been conducted at the level of the business firm or the establishment as a whole, and the technologies deployed has been represented by aggregate measures of inputs of IT capital services (from estimated real stocks of “hardware and software”). Detailed information on the specific IT technologies adopted, the extent and nature of its intra-organisational implementation, and the temporal sequencing of such investments and complementary organisational “redesign” activities have not been be obtained for use in this connection.

As a consequence, a very serious gap exists between the generalisations that econometric analysis has been able to offer regarding the IT-productivity

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<sup>9</sup> As will be pointed out by the discussion in Part III (below), there is a reasonably close similarity between the distributions of responses from organisations that tracked the metric and those that did not track it, for the three measures of performance on which our analysis of “DINT impacts” is focused. That is not the case for all the “metrics” on which the NI 2004 survey reported. Although could reflect a general consensus of opinion among managers of public organisations independent of individual experience, were that the case it is unlikely that we would find that statistically significant differences in estimated performance improvements were associated with objective differences in the organisations’ technologies and implementation practices, as well as with other structural characteristics.

nexus in “private sector enterprise” and the array of more specific questions that business managers, and the vendors and integrators of IT capital equipment would wish to have answered. Here are some among the larger, presently open questions of a generic kind:

➤ Are there strong technical complementarities among the components of the modern digital information technologies that organisations of various kinds now have at their disposal, and which therefore would be reflected in certain “clustered” patterns in the network infrastructure facilities and networked applications which are adopted and deployed?

➤ Are there recognisable “trajectories” along which organisations build up their IT technology capabilities, i.e., sequenced steps on paths that might reflect both underlying key technical complementarities and the constraints imposed by the degree of organisational sophistication that the organisation and its workforce are able to attain?

➤ Among the factors determining an organisation’s investments in IT facilities, what influence is attributable to “technological imperatives” and what effects flow from high-level organisational priorities, from non-technological capabilities, managerial perceptions and expectations?

➤ Is it the case that such “technological imperatives” shape organisational acquisition and deployment behaviours throughout the economy, and therefore that their influence is manifested also in public sector organisations that provide governmental services (both regulatory and informational in kind) and non-commercial health care services (both administrative and clinical in nature)?

To these may be added other, equally “big” questions concerning the validity of the generalisations made about the “organisational performance impacts” of information technologies. With regard to public sector organisations, particularly:

➤ Do variations in organisational purposes and service priorities reflect themselves primarily in the kinds of applications technologies they adopt and the extent to which they deploy them? Or are the profiles of the organisation’s network infrastructure also shaped by such differentiating factors?

➤ Do organisations that are free-standing follow the same patterns of IT acquisition and deployment as to those which are one among a number of “sites” operated by a larger public sector agency?

➤ Are the perceptions on the part of managers regarding the impacts of IT on various dimensions of organisational performance shaped by the objective technological situation of their own organisation? Or are their assessments of the potentialities of the technology formed independently of local experience, and so may primarily reflect a consensus among professional colleagues from other, counterpart organisations, with whom they regularly interact?

➤ Does “nationality” matter in the IT investment practices of public sector organisations? That is to say: if one takes account of objective characteristics of the organisation, such as its purpose, its size, the geographical, demographic and economic correlates of its physical location, its embedded-ness in a larger networked organisational system, and so on, are there significant residual variations in IT adoption and performance impacts that justify distinguishing between German and Italian, or French and British, Swedish or Dutch public organisations?

Most of the preceding questions have not been unanswered hitherto, and indeed, many have not previously been posed in this way. An obvious reason for this is to be found in the unavailability of systematic data on the adoption, deployment and utilisation of IT network infrastructure facilities and networked applications. That has formed a major barrier to addressing these issues about public sector organisations, and so has tended to discourage potential investigators from articulating the questions that naturally would lead to concrete agendas for research on either the determinants or the consequences of differences in the patterns of networked information technology outside the private business sector.

Fortunately, however, a substantial part of that barrier has quite recently been removed by the data collection and analysis project carried out for Cisco Corporation by the Momentum Research Group. The resulting datasets have been made available to the Oxford Internet Institute, and Addendum I.1 presents a description of their scope and contents, along with a commentary on both the strengths and limitations of this material. One will find there a tableau (Figure A-I.1) of the array of data on the structural and digital information network facilities of the organisations covered by the NI 2004 survey of technical decision managers; summary statistics (in Table A-I:1) indicate the gross composition of that (TDM) sample, in terms of the organisations’ regional location, size, and network characteristics. Addendum I.2 offers a number of practical recommendations for the design and fielding of future such surveys, which would not only provide a better basis for addressing some issues that are presently beyond the reach of statistical analysis, but also would enhance the value of the data that has already been collected.

### **Exploring the NI 2004 Survey Data: The Research Programme**

The research exercise on which we report here has used the NI 2004 data to focus on three distinct but interrelated sets of questions. They fall under the following headings:

(1) Macro-level estimates of the current extent of e-network technology diffusion, and projections of near-term and planned adoption rates.

(2) Technology-specific patterns of adoption, and identification of salient distinguishing features of the organisational “profiles” of DINT acquisition and deployment.

(3) The relationships between micro-level estimates of changes occurring in selected aspects of organisational performance (with respect to “productivity” and customer/client satisfaction), on the one hand, and, on the other hand, the organisation’s objective DINT “endowment” and way in which it utilises its network infrastructure and network applications.

There is an apparent degree of commonality with the issues treated in the Momentum Group’s *Net Impact 2004* report, inasmuch as the latter was oriented towards assessment of the conditions surrounding technology acquisition in the public sector, and the estimated effects or “impacts” this has had on the performance of adopting organisations. Regarding the first, technology adoption aspect, the NI 2004 survey obtained an almost overwhelming array of information for each organisation from its IT department respondent (*technical decision managers*, or TDMs, hereinafter) about the presence of many specific elements of “networked infrastructure and applications” (and more specifically “Internet-based” applications). By using the observations on the types of network services, and the types of network applications that have been adopted, one can build up measures of the extent of inter-organisation diffusion for various sub-populations within the public sector. Similarly, individual and average intra-organisation diffusion measures based on the extent of implementation (percentage of personnel with access) can be formed for each of the specified networked applications.

Diffusion measures of this kind are intrinsically interesting, as they enable one to gauge how far the public sector and its component organisations have progressed towards achieving “connectivity” – in reference either to their own plans, or to the contemporary situation prevailing in the business sector. Moreover, the interrelationships among the various components of infrastructure services and networked applications are pertinent in providing a characterisation of the organisation’s overall “digital information network technology” profile, and identifying the major distinguishing features of the different technology profiles among which the public sector organisations are currently distributed. Part II of this study presents the initial results of this approach to the data, which will be seen to demonstrate potential its potentialities for addressing important macro- and micro-level issues that the *Net Impact 2004* report did not seek to address.

In Part III we bring some of the findings from Part II -- particularly those relating to the main patterns or “profiles” of DINT adoption – to bear on the question of how these technologies are affecting the performance of public sector organisations. The issue of organisational efficiency is a central concern of the NI 2004 report, in which the term “efficiency” is used both broadly and narrowly: broadly in referring to the performance of service provision to clients

(whether external to the organisation or to other units) and narrowly in regard to metrics relating task completion to a measure of input.

Strictly speaking, efficiency and productivity are measures of relationships between outputs and inputs, however measured. Some so-called "efficiency" indicators in the Momentum Group's study relate only to organisational service outputs, and some to effort inputs, whereas only a few of them afford ratio comparisons between the two – namely, the number of cases resolved per employee, which could be adjusted by the average time for case resolution to provide a measure of case resolution per employee (hour/day/week). This would be an interesting labour productivity measure to be able to study. Unfortunately, neither it nor the other measures just mentioned are available, because the surveys of technical and business decision managers did not ask for actual data about those dimensions of organisational performance; not even in those instances where (in the BDM survey) managers reported that their organisation was tracking the metrics in question.

Consequently, cross-section comparisons of performance levels and analysis of changes in levels associated with DINT acquisition and implementation are not possible using these data. Instead, what we can examine is the cross-section of business managers' subjective estimates ("perceptions") of the percentage changes in the various performance metrics -- which were solicited both from organisations that tracked the metric and from those that did not. Furthermore, because the absolute levels are not known, one cannot use the estimated percentage change in average time to case resolution to adjust the change in average case resolution per employee. Consequently, even the latter indicators of proportional impacts must be left in unrefined form.

Nevertheless, the business managers' responses to these questions about "impacts" constitute a unique body of information which, if used with due care, may reveal valuable information about the connections between technology acquisition and implementation behaviours, and changes in organisational performance. At least this is the case for the sub-sample in which both IT manager responses and business manager responses are available. The Momentum Group's report does not bring the two together explicitly, nor does it systematically relate the organisations' respective network infrastructures and deployment of networked applications to one another. The association between these technology acquisition measures and various indicators of the organisations' technical capabilities and limitations, and managerial priorities and attitudes regarding the utilisation of digital network technologies, would provide a particularly rich analysis of the IT adoption process in public sector organisations. Indeed, this would be a step forward in research on the microeconomic factors affecting decisions to adopt

digital information network technologies in organisations of all kinds, private as well as public.<sup>10</sup>

For the purposes of this exploratory study, however, the analysis of the TDM survey data described in Part II is confined to characterising the current and projected “technology profiles” of these public organisations, and, in effect, classifying each organisation as belonging to one or another of the main technology profile clusters that we have been able to identify by statistical analysis. The distribution of organisations of various types among those clusters, and the representation of the distinct technology profile clusters among the organisations in the TDM sample population, are among the novel and interesting findings of Part II. These results, moreover, will be seen to provide one of the foundations for the new findings on organisational performance “impacts” in Part III.

Part III presents the results of a pilot statistical analysis of a subset of 246 cases for which the two bodies of survey data can be integrated: it focuses on the determinants of the estimated rates of change in three performance indicators -- average time for resolving cases, average number of cases resolved per employee, and customer/client satisfaction with the services being provided – as reported by the business decision managers of organisations that actually tracked the metric in question.<sup>11</sup>

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<sup>10</sup> Systematic study of the adoption of within-establishment Internet technologies by business firms has only recently begun, notably by C. Forman, A. Goldfarb and S. Greenstein, “How did location affect commercial adoption of the Internet?: global village vs. urban leadership,” forthcoming in *Journal of Urban Economics*, 2005; “Technology adoption in and out of major urban areas: when do internal firm resources matter most?,” NBER Working Paper 11642 (September) 2005 [available at: [www.nber.org/papers/w11642](http://www.nber.org/papers/w11642)]. While the available data is vastly greater in terms of numbers of observations on business units, the econometric research on adoption that it can support has, thus far, remained considerably less detailed than that which can be carried out on the basis of the NI 2004 dataset. In the latter context it would be possible to examine the degree to which there is agreement between the two sources of managerial views (TDM vs. BDM) in each organisation as to priorities and expectations regarding the effects of its informational technology-related investments. In turn, measures of the degree of alignment of those views may be associated with variations in estimated impacts. Furthermore, it should be possible to enhance our understanding of the determinants of network technology adoption and its mode of utilisation by examining the latter, objective attributes of the organisation in conjunction with the technical decision manager’s appraisals of the adequacy of budgetary, managerial and staff support that their department receives from the organisation’s leaders. These questions, along with many others, have been left for future study.

<sup>11</sup> This analysis, like that of the patterns of adoption in the entire TDM dataset, may be further enriched by the use of the ecological information obtained by tying the telephone dialling codes – at least for 5 of the countries surveyed. Further, because we have the technological profile and objective characteristics of the full IT manager’s survey, it is possible to make corrections for selectivity bias in the sub-sample—and thereby show how the relationships found will apply to a wider array of public sector organisations. This has been left for future work, as the issue did not appear very serious: preliminary examination of the composition of the BDMM sub-sample and the TDM sample shows substantial similarities in the distributions of their main structural (non-technological) characteristics, i.e., type, employment size and national locations.

## Necessary caveats

As interesting and, indeed, important as we believe are the findings of this study concerning the connections between the performance of public sector organisations and the investments made in their acquisition and mode of utilising e-network technology facilities, more than one note of caution needs to be sounded at this point. Quite aside from the numerous constraints imposed by the nature of the available data (about which more is said in the Addendum to Part I), and beyond the limitations owing to the simplified methods of statistical analysis that we have chosen to apply in view of the small sample sizes on which the analysis of organisational performance "impacts" is based (in Part III), the very meaning of "organisational performance improvements" in this context is surrounded by ambiguities that should be borne in mind when interpreting the results presented on this question.

The nub of the deeper, unresolved ambiguity is this: "performance" may be defined and measured either from the perspective of the "server" or from that of the "served," and the two assessments need not concur. Indeed, they may be inversely associated. For example, "resolution" of cases/requests can be defined in terms of executing a transaction in which information is supplied in response to an enquiry. The requestor may be given incorrect information, or correct information that does not address their need because the latter was not properly elicited in a brief or pre-programmed request process. This may generate a second request, which also can be "resolved," and so it is quite possible that increased "efficiency" in the task of "case resolution"--although leading to more cases resolved per employee, and faster average resolution time per case -- may not translate into greater "productivity" in addressing the problems that led to cases being presented for resolution. To infer that the welfare of those being served is enhanced when productivity in resolving their cases is raised requires defining, and adhering to some "client-relevant" standard of service quality. The latter standards are quite difficult to define, in part due to the heterogeneity of individual requests, or "cases", but in the absence of such a standard one must acknowledge that there is a shroud of uncertainty: "requests resolved" per employee may show improvement, and adjustments for speed of resolution could be viewed as revealing even greater "quality-adjusted" gains, even when the number of repeat requests per client case, not to mention client time and frustration, would suggest just the opposite trend when organisational performance was evaluated in terms of clients utility. Clients who discontinue attempts to obtain a service, and have their place in the queue taken by others have not had their "cases" resolved in terms of their satisfaction, even if the organisation is able to "close" the case file that bears their reference number.

Thus, it continues to be essential to stress that where the public services involved are un-priced transactions, and where some of the transactions are mandatory for the clientele, an index of improvements in task performance rates per unit of input can tell us something about changes in organisational

unit costs. But that notion of "productivity" does not automatically admit of the conventional economic welfare being assigned to "output" as a proxy for consumer satisfactions. This is not the case where one is considering priced commodities and the quantity of goods and services delivered can be evaluated at relative prices, because there it can be said that under conditions of perfect competitive equilibrium the relative prices would reflect the relative marginal utilities (satisfactions) from consumption of the good involved by rational, utility-maximising consumers.

One must therefore be alert to the possibilities that changes in the mode of task performance that register as unit cost improvements may have altered the attributes of the service in ways that do not yield correlated reductions in the social costs of client satisfaction. Absent independent evaluations of the output from the clients, one cannot escape this fundamental ambiguity which surrounds the economic welfare meaning of such results we have been able to obtain.



## PART II

### **e-NETWORK TECHNOLOGY DIFFUSION IN THE PUBLIC SECTOR: MACRO- AND MICRO-LEVEL PATTERNS AND IMPLICATIONS**

This Part summarises the patterns of technology adoption by organisations in the public sector, as identified by analysis of their deployment and implementation of network services, networked applications and wide-level of deployment within organisations. We begin in section 1 by presenting the results of aggregating several more detailed measures of inter-organisation diffusion of network services and networked applications constructed from the NI 2004 survey data, in order to obtain macro-level estimates of the extent of adoption of the main classes of digital information network technologies in all 8 of the countries covered by that survey.<sup>12</sup> The resulting macro-level estimates provide not only a view of the current extent of diffusion of e-network technologies in the public sector as of the beginning of 2004, but also near-term projections of the same measures that are based upon responses of technology decision managers to survey questions about the respective organisations' specific adoption plans. Although the resulting estimates are far from precise, to the best of our knowledge they are the first of their kind for the European public sector. What these prospective trends in technology diffusion may imply about the expected pace of sector-wide improvements in organisational performance measures (such as the number of cases resolved per employee) is a question of obvious interest, on which our exploratory results make it possible to offer some empirically grounded conjectures.

The following sections unpack the aggregate picture and present a number of the underlying patterns in the adoption of the array of constituent network services and networked applications, and in the extent of the intra-organisation deployment of the latter. We then discuss the results obtained by applying the technique of cluster analysis in order to identify several distinctive "technology profiles" that characterise these organisations. The statistical method we employ assigns every organisation in the TDM sample to one of three clusters in each of the following dimensions of their technology profile: the array of services available on the network, the available array of networked applications, and the relative extent to which the organisation's employees are afforded access to its networked applications. We are able to rank order the clusters found for each dimension, according to their relative levels of technology acquisition (and deployment) profile it represents, and then examine the distribution of organisations of different employment sizes, regional location, and type at these distinct profile levels.

The last section within this part presents the results of developing a summary profile of each organisation's e-network technology status (at the survey data), obtained from a "meta-cluster" analysis. We are able to identify

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<sup>12</sup> France, Germany, Italy, the Netherlands, Poland, Spain, Sweden and the United Kingdom.

five distinctive “profiles” among the 1112 organisations represented in the TDM dataset by clustering them on the basis of their respective assignments to clusters in each of the three specific dimensions previously discussed, and their binary classification with respect to two other features of their network infrastructure and networked applications. The “meta-clusters” also can be ranked according to the general level of sophistication and comprehensive deployment of the technologies that each represents, and it is therefore possible to examine the characteristics of the organisations that are grouped at each of those “levels.” By the same token, we are able to describe the way in which organisations of a given type (e.g., national government, or regional government, or hospitals and laboratories in the health sector) are distributed along an ascending scale of “technology profile levels.” We close by remarking on several salient patterns that this “data reduction” approach reveals, and their implications they may be thought to carry concerning the dynamic paths of e-network technology acquisition and use along which Europe’s public sector organisations appear to be moving.

## **1. Macro-Patterns of Diffusion and the Implications for Productivity**

Our view of the macro-level state of diffusion of e-network technologies in Europe’s public sector, as of the end of 2003, is presented in Table II-1 (below) in the column on the extreme right, headed D(1), describing the “actual extent of adoption by connected organisations.” The entries in this column refer to the proportion of all the organisations that reported currently having adopted the specific network services and networked applications belonging to the main categories described by the notes to the table.<sup>13</sup> The other two columns of the table show corresponding measures of the extent of inter-organisational adoption projected to future dates, on the basis of technology decision managers’ responses to questions about developments underway at the time of the survey and future plans. The measure D(2) augments the D(1) measure by adding the counts of organisations with system developments currently in progress and the planned adoption counts from those organisations that had such work fully budgeted for the next 12-months. D(3) augments measure D(2) by adding the planned adoption counts from organisations that did not have future technology acquisition budgeted at the time of the 2003 survey.

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<sup>13</sup> These estimates were constructed by first calculating the proportions D(1) for each of the underlying constituent technologies in each of the 8 countries, and then averaging the results to obtain (for each country) the six technology classes shown in the rows of Table II-1. The country-specific average measures for each class were then aggregated, weighting the measure for each nation by its approximate share of the total number of public sector employees in all 8 countries combined. This scheme gives Poland a comparatively large weight in the aggregate diffusion measures, as can be seen from the following shares in the total: FR-0.166, GER-0.180, IT-0.103, NL-0.064, POL-0.193, SP-0.083, SW-0.44, UK-0.167. Corresponding calculations made for the 7 country aggregate, excluding Poland, show very much the same pattern both as that appearing in Table II-1.

One may regard the D(3) measure as reflecting the technology decision managers' "aspirations", but it seems just as reasonable to treat it as a projected extent of diffusion at the end-point of a 5-year planning horizon, i.e., at the close of 2008. The measure D(2) if analogously interpreted gives us a projection for an intervening date, but regardless of whether that date is imagined as falling two years rather than three years before the 2008 horizon, the implication remains that the upward trend of the extent of diffusion will be slowing for all the technology classes shown in Table II-1.

**Table II-1**  
**Estimates of Overall Inter-Organisation Extent of Diffusion of e-Network Technologies in Europe, 2004**  
 (Based on Weighted Employment Estimates in 8 Countries)

<u>Current Diffusion Extent (percentage) relative to:</u>			
	Projected Maximum for Connected Organisations (D3)	Actual and Planned of Connected Organisations (D2)	Actual of Connected Organisations (D1)
<b><u>Network Services Groups</u></b>			
Security and Recovery	91,26	83,86	69,01
Data and Document Management	70,00	50,97	25,42
Communications	76,44	55,06	23,43
<b><u>Networked Applications</u></b>			
Organisational Control	85,25	83,82	75,75
Client/Customer Relations	69,65	61,93	43,15
Internal Management Operations	68,00	60,99	39,16

**Notes to Table II-1:**

These values are weighted for differences across the 8 countries in terms of employment in the public sector.

**Typology of Network Services and Network Applications**

**Network Services**

**Security and Virus-Protection** (includes Server Based Virus Detection and Containment and Real Time Intrusion Detection); **Data and Document Management** (includes Remote Disaster Recovery Sites, Storage Area Networks and Content Caching); **Communications** (includes Integrated Network for data, voice and video, Wireless LAN, Optical Networking, Voice over Internet Protocol, Internet Protocol Telephony and Virtual Private Networks).

**Network Applications**

**Organisational Control** (includes Finance and Accounting and Human Resources); **Client/Customer Relations** (includes Customer or Citizen Relationship Management and External Web Portals); **Internal Management Operations** (includes Content Management, Decision Support and Knowledge Management, Document Management, Resource Planning and Optimisation, Internal Web Portals).

Unweighted averages of the 8-country measures (D(1) and D(3) for each of the network services and the networked applications that are grouped in Table II-1 are displayed graphically in Figures A-II:1 and A-II:2 of the Addendum to Part II. These may be consulted to confirm that the patterns exhibited by the technology group in the above table are not artefacts of either the definitions of the subgroups, or the weighting of the underlying country diffusion measures by the relative shares in total public sector employment.

Among the network services the most widely adopted sub-class are the security and virus-protection technologies (particularly, server-based virus detection). Inasmuch as these may be regarded as the most basic of the infrastructure services, it is not surprising that the current aggregate diffusion measure is as high as 69% of the region's (employment-weighted) public sector organisations, and the near-term planned extent of diffusion is projected to reach the 91% level.<sup>14</sup> By contrast, the current diffusion measures for Data and Document Management services and Communication services stands at only 25%, and, although projected to rise quite quickly in the near-term, the maximum level of diffusion that is projected for these services does not much exceed the 69% mark.<sup>15</sup>

A parallel difference appears between the levels of the diffusion measures for the three classes of technologies belonging to the Networked Applications group. Again, it is the basic Organisational Control applications -- including Finance and Accounting and Human Resources, which are more or less essential for carrying out basic back-office managerial control and reporting functions for the organisation -- that currently are even more widely used among public sector organisations than the basic network services. Overall, these applications were available in more than three-quarters of the (weighted) public sector organisations, a level rather higher in relation to their own projected maximum extent of diffusion (D(3)=85%) than was the case for the counter-part "basic" category among the network services. This contrast is likely to be a reflection of the fact that the use of these basic applications technologies already was widely established in an earlier wave of "computerisation" of these public organisations, preceding the subsequent move to Internet connectivity.

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<sup>14</sup> Although VPN (virtual private network) service is grouped among the Communications category of Network Services, for the purposes of constructing Table II-1, an alternative classification might well place it in the virus protection and security group on the ground that for organisations that have installed local firewalls for security purposes, VPN is required in order for their personnel to have remote access, and to afford access to resources external servers that are within the organisation's WAN-connected sites. It should therefore be noted that the extent of current inter-organisation diffusion of VPN services averages slightly over 50% among the 8 countries (on an unweighted basis), putting it above the Communications average and closer to the levels shown in Table II-1 for the security and virus protection services.

<sup>15</sup> The D(3) index is shown as reaching the 76% mark for the entire communication services group. But, it should be noticed that although VPN (virtual private network) service has been included here under the heading of Communications, for those organisations that are not free-standing and which have installed firewalls to provide security and virus detection, the provision of VPN for employees working at or drawing on data resources at sites in the organisation is really closely complementary with the already more widely diffused "basic" network infrastructure services that are grouped under "security and recovery". Not surprisingly, therefore, it is observed that the current and projected future diffusion measures for VPN are substantially above those for the other communication services, as may be seen from Figures II-1 and II-2. Therefore, if VPN were excluded from the category of communications, the level of the diffusion measures for the (other) communications services category would resemble that for data and document management services even more closely.

Compared with the class of Organisational Control applications, both Client/Customer Relations applications and Internal Management applications are less widely diffused. Currently adopted among 43% and 39% of the sector's organisations, respectively, their D(1) levels stand above those of the Data and Document Management and Communication services, but the projected maximum extent of diffusion, D(3), in both cases just approaches the 70% level. Client/Customer Relations applications is oriented to the management of external transactions with the citizens and firms, and, emblematically includes External Web Portal applications, in contrast with the Internal Portal applications and the variety of inward-oriented applications (such as decision support, knowledge management, resource planning and optimisation) that make up the Internal Management category. It is rather striking that the adoption levels and the projected paths of diffusion for these outward- and inward-oriented applications appear to be so closely aligned and are projected to remain that way. Evidently, seen at this very high level of aggregation, Internet connectivity in and of itself is not disturbing the balance between the internally- and externally-oriented functions being carried on by European public sector organisations.

The macro-level diffusion estimates in Table II-1 provide a basis for roughly gauging not only the current extent of diffusion of e-network technologies, but, also the approximate trend rates of increase in basic and more advanced classes of network infrastructure and networked applications over the near-term period between 2003 and 2008 -- if one is prepared to associate the projected D(3) measures with a five year "planning horizon." Given such information about the level and the pace of advance in the extent of diffusion, the impact that these trends will have upon the rate of growth of average organisational performance for the public sector may readily be calculated -- given one additional piece of data. What one needs to know is the average proportional increase in the metric (or metrics) of organisational performance that is associated with adoption of the innovative technology (or class of technologies). Estimates of just such "impacts" are the subject of the discussion in Part III of this study, so it is of interest at this point to take note of what those findings imply when considered in conjunction with the macro-level trends that have just been examined.

For the purpose of that illustrative exercise we focus on only one set of our findings about organisational performance improvements. These relate to the proportional gain in a measure of labour productivity, namely, the rate of growth in the volume of "cases resolved" per employee that can be associated with the adoption and implementation of particular configurations of network service and networked applications technologies by specific types of public sector organisations.<sup>16</sup> Rather remarkably these two, independently derived

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<sup>16</sup> The estimates referred to are those in Table III-1 (Panel 2). The Addendum to Part II: "Notes on Diffusion and Aggregate Labour Productivity Growth" describes both the theoretical model on which these calculations are based, and the way in which the micro-level estimates of labour productivity "impacts" presented in Part III have been used to obtain a weighted overall estimate of the average

empirical results fit together to imply an entirely plausible aggregate outcome: average annual trend growth rates of aggregate labour productivity in the generic public sector organisation task of “case resolution” that range from 2.2 to 5.6 percentage points per annum. These magnitudes are comparable with the pace of advances of aggregate labour productivity in the U.S. private domestic economy since the late 1990’s, which has seen an acceleration of the productivity growth rate within that range that is widely attributed by macroeconomists to the cumulatively rising impact of ICT-embodied capital formation and the associated reorganisation of production.

It is consequently relevant to note that the lower of our pair of growth rate estimates corresponds to just the compositional effects of the migration of the population of public organisations to more advanced levels of adoption of the existing array of e-network technologies in use c. 2003. The upper estimate allows, in addition, for the indirect productivity enhancements (of 3.3 percentage points per annum) due to induced, experience-based improvements in the efficiency of the available technologies in these applications. Therefore, these conjectural findings reinforce the plausible expectation that a quickening of the public sector’s aggregate productivity performance in these simple tasks would materialize towards the latter part of the 2003-08 period. But, as the discussion of these estimates in the Addendum to Part II (section A-II.2) points out, one may reasonably suppose that the indirect, learning effects and spillovers would make their impact on productivity growth felt only with some lag. Hence they would be concentrated in the period 2005-08 and combine with the slower direct productivity growth rate of 1.6 percentage points per annum that is calculated for that interval. The result would be an overall trend growth rate of 4.1 percentage points per annum during 2005-08, representing an acceleration from the 2.9 percent per annum average growth rate over the period 2003-06. Taking the geometric average of the overlapping first and second sub-periods, the scenario thus envisaged would generate a 3.5 percentage point average annual pace of labour productivity advance in public sector organisations for the whole of the period 2003-08. That figure turns out to coincide with the geometric average of the upper and lower estimates in the 2.2 to 5.6 percentage point range that was cited above.

As interesting and plausible as the magnitudes and timing suggested by these estimates may be, it has to be stressed that they not only rest upon survey data whose representativeness remains undetermined in several important respects, but that numerous assumptions and approximations have been made in order to piece together the underlying component estimates —as is described by the empirical implementation notes in the Addendum to Part II. Rather than presenting the foregoing aggregate productivity growth rates as a reliable forecast, they have been produced primarily to show the connection between the subject matter developed in Parts II and III of this study. They exemplify in a concrete fashion the analytical proposition that the aggregate

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proportional gain sector-wide average labour productivity in this one generic task (“case resolution”).

rate of labour productivity growth in the public sector in the years ahead will be shaped by the interaction between the pace of inter-organisation technology diffusion, on the one hand, and, on the other hand, the micro-level adoption and implementation behaviours that affect the impacts that these net digital information technologies have on the average gains achieved in the “task productivity” of employees with these organisations. That our results under both headings fit together in so reasonable a way is surely satisfying, but the precise results should not be taken too literally.

## **2. Micro-Patterns in Adoption and Deployment**

Further evidence suggestive of the existence of a dynamic progression of organisations along paths leading to higher levels of technology acquisition and deployment is provided by the results of applying the technique of “k-means” cluster analysis to the observations on the use of network services and networked applications data by the 1112 organisations of the TDM survey. This procedure begins, in effect, by treating all individual organisations as belonging to a single cluster in regard to the pattern of technology usage in a specific dimension, such as the network services that currently are installed and carrying live traffic. A particular “similarity” or “distance” algorithm then sequentially partitions the observations into distinct “clusters” whose internal resemblances increase with each step in the partitioning.<sup>17</sup>

### ***Technology profiles from cluster analysis***

For the purposes of this exploratory analysis, in which the cluster assignments were intended to be used in the next stage of the study to parsimoniously characterise each organisation’s technology for purposes of the analysis in Part III, the number of clusters sought in each dimension of technology was arbitrarily fixed at 3. The resulting triplets of clusters that emerged from this statistical procedure describe “profiles” of increasingly more comprehensive technology acquisition in each of the technology dimensions that were examined -- network services, networked applications, and the intensity of intra-organisation deployment of networked applications. (See Addendum to Part II.2 for further details showing the “cluster centers” that indicate the characteristic technology-profile associated with each cluster, and hence reveal the basis for ordering them in ascending levels.)

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<sup>17</sup> For a general treatment of clustering methods, see A. K. Jain and R. C. Dubes, *Algorithms for Clustering Data*, New Jersey: Prentice Hall, 1988. The “k-means” algorithm, such as the standard algorithm due to Lloyd (S. P. Lloyd, “Least squares quantization in PCM, *IEEE Transactions on Information Theory*, IT-28, 1980: pp. 129-137) uses cluster centroids as reference points in subsequent partitionings, starting from an arbitrary partition of the observations centroids; centroids are adjusted during and after each partitioning by reassigning points among the clusters (partitions) so as to minimize a generalisation of the within cluster variances, found as the square of the absolute distances of points from the reference point. After each iterative step, every one of the reference points is a centroid, or mean – hence the name “k-means.” The k-means procedure is available on SPSS v.13+.

The following tables allow us to describe the way in which the surveyed public sector organisations belonging to three main employment size classes in each of three main geographic regions (North, South, and East) of Europe are distributed among the clusters in these technology-use dimensions. An alternative arrangement of the same information (the cluster assignments of each organisation in the TDM sample) shows regional and size composition of the organisations that belong to each of the clusters. The cross-section variations that emerge from this exercise are quite consistent with the interpretation of the organisations being distributed across successive stages of technology acquisition and deployment, in which the leaders are found disproportionately among the larger organisations of the Northern European region. This will be seen to be a quite pervasive feature of the patterns found in each of the technology-us dimensions, starting with the network services:

- One of the clusters (Cluster TNS1, including 542 organisations) has only currently implemented basic security and recovery technologies (specifically Server based virus detection).
- A second cluster of 351 organisations (Cluster TNS2) have in addition to basic security functionality also implemented Real time intrusion detection as well as some basic communication technology (specifically virtual private networks).
- Finally, only 219 organisations have currently implemented all the other types of technology (excluding Voice Over IP technology, Cluster TNS3).

Results from the clustering of organisations with regard to their level of implementation of networked applications, also reveals some interesting differential patterns of technology diffusion.

- The majority of organisations (414) have only implemented Finance and Human Resources applications (TNA3 cluster).
- A group of 332 organisations has currently implemented Internal and External web portals, in addition to the “basic” organisational control applications (TNA2 cluster).
- A third cluster of 366 organisations reports implementation of the whole set of networked applications (TNA1 cluster).

It may be remarked at this point that countries in the South (Spain, Italy) and East (Poland) report current levels of implementation of Internal Web Portals and External Web Portals higher than in the North. This reveals some process of “leap-frogging” by the use of newer and available technology at later stages of implementation.

When analysing the relative extent of deployment of the various networked applications using web technology, very clear and differentiated clusters also emerge:



- A large proportion of organisations (cluster of 721) do not deploy network applications widely for more than 20% of workgroups within their organisations.
- An additional number of 229 organisations only deploys to their workgroups the more basic Finance and Human Resources and Human Resources Optimisation applications.
- Only 162 organisations deploy to more than 40% of their internal workgroups Citizen Relationship management applications and Human Resource Optimisation applications.

The empirical validation of the dynamics of the technology adoption process that we have hypothesized in the foregoing discussion would require a longitudinal study of a panel of organisations for a significant period of time. This clearly is beyond the scope of the present (cross-sectional) investigation. Nevertheless, the above analysis reveals some evidence of progression along similar technology diffusion paths by public sector organisations across Europe.

### ***Region- and size-specific variations in organisations' technology profiles***

Notwithstanding the suggestion of a widely shared trend, significant differences were identified among the 8 countries in terms of their technology adoption profile, as well as among organisations of different sizes and even between the "government" and "healthcare" sub-sectors. We analyse these different patterns in the following sections.

Several noteworthy regional patterns in the distribution of organisations at the different stages (or levels) in the acquisition of these technologies are immediately seen from the results displayed by Table II-2.

- Organisations with more advanced technology profile in terms of extensive deployment of their network applications are largely concentrated in the North (52%). The South represents 42% and the East only 6%.
- 61.2% of the organisations having a more advanced network services profile also are located in the North region. The South represents 35.6% and the East 3.2%.
- For the intermediate technology profile group, the North also represents 57.3% in terms of organisations with this profile of network applications and 59.2% of network services. The South accounts respectively for 37.4% and 37.6% of the total number of organisations in this technology profile.
- The South almost matches the North in the share of organisations having only a basic technology profile: having 40.3% against the North's 50.7% for network applications, and 43.5% against 45.7% for network services.
- Organisations in the large (employee) size class that are located in the North, and those in the intermediate size class are located in the South

account for 44.8% of all the organisations in the advanced technology profile group of network applications. They also account for 50.7% of all the organisations in this advanced profile group in terms of network services.

Table II-3 provides additional information on differential patterns of technology acquisition, by showing the distribution of organisations for each region, and by different size categories, over each of the 3 technology profiles (clusters) for network services, and then for networked applications. This new arrangement of the results of the cluster assignments allows the comparison of organisations with different sizes and their technology profile for each region, and thereby reveals a repeated pattern in the relative concentrations of organisations of different types among the network service clusters, and network applications clusters.<sup>18</sup>

**Table II-2**  
**Different Patterns of Implementation of Networked Applications and Services**  
 Distribution of Clusters by Regions and Size of organisations

			Network Applications: Cluster Number			Total	Network Services: Cluster Number			Total
			TNA1	TNA2	TNA3		TNS1	TNS2	TNS3	
North	Large	%	24.6%	25.9%	15.7%	21.7%	12.9%	27.6%	33.8%	21.7%
	Medium	%	11.2%	17.2%	19.1%	15.9%	16.2%	17.1%	13.2%	15.9%
	Small	%	16.1%	14.2%	15.9%	15.5%	16.6%	14.5%	14.2%	15.5%
South	Large	%	10.9%	13.9%	7.7%	10.6%	7.7%	14.2%	11.9%	10.6%
	Medium	%	20.2%	16.9%	20.5%	19.3%	22.9%	15.4%	16.9%	19.3%
	Small	%	11.2%	6.6%	12.1%	10.2%	12.9%	8.0%	6.8%	10.2%
East	Large	%	.8%	.3%	.7%	.6%	.2%	1.1%	.9%	.6%
	Medium	%	1.4%	1.5%	2.4%	1.8%	3.1%	.9%	0.0%	1.8%
	Small	%	3.6%	3.6%	5.8%	4.4%	7.4%	1.1%	2.3%	4.4%
Total	Count		100% (366)	100% (332)	100% (414)	100% (1112)	100.0% (542)	100.0% (351)	100.0% (219)	100.0% (1112)

**Notes to Table II-2**

Technology Profiles in the Implementation of Networked Applications

- TNA1: More "advanced technology profile"
- TNA2: Intermediate technology profile
- TNA3: Basic Technology Profile

Technology Profiles in the Implementation of Network Services and Technologies

- TNS1: Basic Technology Profile
- TNS2: Intermediate technology profile
- TNS3: More Advanced technology profile

<sup>18</sup> These are readily seen by comparing the percentages in the right-most columns of each panel in Table II-2 with the percentages entered for the several clusters in the body of the table.

Several rather interesting conclusions can be drawn from these results:

- Smaller organisations have a more “basic technology profile,” in relative terms, than do intermediate size and larger organisations – with regard to both network applications and network services. This is generalisation applies across all three of the main regions shown in the tables.
- In the South especially, and to a lesser degree in the other two regions, smaller organisations are comparatively further advanced in regard to network applications deployment than they are in regard to network services and infrastructures. (The same applies in the case of medium size organisations in the South, but the differences are less pronounced.) The lag in the latter dimensions is likely to reflect the comparative state of development of the regional telecommunications markets more generally, as well as other “contextual” variables. Large organisations in Poland perform relatively much better in terms of network services, which again reflects to some extent the market structure of telecommunication markets and the overall structure of the public sector.

**Table II-3**

**Different Patterns of Implementation of Networked Applications and Services**

Organisations in Regions and Size Categories distributed by cluster

		Network Applications: Cluster Number			Total	Network Services: Cluster Number			Total
		TNA1	TNA2	TNA3		TNS1	TNS2	TNS3	
North	Large	37.3%	35.7%	27.0%	100.0%	29.0%	40.2%	30.7%	100.0%
		90	86	65	241	70	97	74	241
	Medium	23.2%	32.2%	44.6%	100.0%	49.7%	33.9%	16.4%	100.0%
		41	57	79	177	88	60	29	177
	Small	34.3%	27.3%	38.4%	100.0%	52.3%	29.7%	18.0%	100.0%
		59	47	66	172	90	51	31	172
South	Large	33.9%	39.0%	27.1%	100.0%	35.6%	42.4%	22.0%	100.0%
		40	46	32	118	42	50	26	118
	Medium	34.4%	26.0%	39.5%	100.0%	57.7%	25.1%	17.2%	100.0%
		74	56	85	215	124	54	37	215
	Small	36.3%	19.5%	44.2%	100.0%	61.9%	24.8%	13.3%	100.0%
		41	22	50	113	70	28	15	113
East	Large	42.9%	14.3%	42.9%	100.0%	14.3%	57.1%	28.6%	100.0%
		3	1	3	7	1	4	2	7
	Medium	25.0%	25.0%	50.0%	100.0%	85.0%	15.0%		100.0%
		5	5	10	20	17	3		20
	Small	26.5%	24.5%	49.0%	100.0%	81.6%	8.2%	10.2%	100.0%
		13	12	24	49	40	4	5	49
Total	Row %	32.9%	29.9%	37.2%	100.0%	48.7%	31.6%	19.7%	100.0%
	Count	366	332	414	1112	542	351	219	1112

**Differences in technology profiles among functionally distinct organisations**

A fourth way of looking at the data through the lenses of these technology-use clusters is to consider the variety of organisation types – distinguishing within the broad classes of “government” organisations and those forming the “healthcare” sub-sector. With regard to each of the seven main functional types we have identified in the TDM survey dataset, one may ask: What is the representation of these organisations within each of the clusters that distinct technology profiles for each of the several dimensions? Table II-4 present the distributions that enable one to answers this question about the organisational constitution of the clusters identified for network services and networked applications dimensions.<sup>19</sup> The comments that follow touch upon the highlights.

**Table II-4**  
**Distribution by Sector Type of Public Organisations:**  
**“Government” and “Healthcare”**  
 Distribution of Organisation types within Clusters

		Network Applications: Cluster Number			Total	Network Services: Cluster Number			Total
		TNA1	TNA2	TNA3		TNS1	TNS2	TNS3	
National government	%	4.4%	10.2%	3.4%	5.8%	4.6%	6.3%	7.8%	5.8%
R/L Gov	%	46.2%	45.2%	49.8%	47.2%	48.9%	46.7%	43.8%	47.2%
Oth Gov	%	2.5%	3.0%	2.9%	2.8%	1.8%	3.4%	4.1%	2.8%
Cli/Car	%	16.1%	8.7%	16.7%	14.1%	15.5%	12.8%	12.8%	14.1%
Ho/Lab	%	14.8%	18.7%	16.4%	16.5%	16.8%	17.7%	14.2%	16.5%
Other Health	%	12.6%	11.4%	8.0%	10.5%	8.9%	10.5%	14.6%	10.5%
Oth in/R	%	3.6%	2.7%	2.9%	3.1%	3.5%	2.6%	2.7%	3.1%
Total	N	366	332	414	1112	542	351	219	1112

- Organisations in the Regional and Local Government represent 45-46% of the total number of institutions in the two more advanced applications technology profiles (TNA2 and TNA1), respectively. Those shares are in each case a shade below their proportional representation in the population; correspondingly, it is seen that this group is somewhat “over-represented” in at the most basic of the profile levels (TNA3). But, the former observation holds also in regard to network services, where these government organisations are relatively over-represented at the lowest profile level (TNS3), and progressively more under-represented at the higher profile levels. National and Other Government together make up only 8.6% of the total sample. While they are each relatively concentrated at the intermediate

<sup>19</sup> Corresponding distributions for the Networked Applications Deployment (TNAD) clusters are given by Talbe A-II.3:3 in Addendum to Part II.

profile level for networked applications, they bulk relatively large among the organisations at the higher profile levels for network services.<sup>20</sup>

- Hospitals and Laboratories are the largest single group of the three within the health sector, accounting for almost one-third of its total number of organisations (16.5% vs. 47.1% for the sub-sector in toto). Like the national government units, they are relatively concentrated at the intermediate profile level with regard to applications, but at the advanced level of network services. Other Health units (where the organisations dealing with healthcare insurance are classified) exhibit the same relative concentration, indeed, in a somewhat more pronounced manner.
- The Clinical and Healthcare units present an anomalous pattern of relative concentration with respect to the clusters in both the networked applications and network services dimensions: they are relatively strongly over-represented at the most advanced and the most basic levels. This bimodality raises a suspicion that the category is mixing two types of organisations whose priorities in regard to e-network technologies are rather different: the health care units may resemble the less technically advanced regional/local government organisations, whereas the clinics' use of these information technologies is more akin to that found among the local government units.

The cluster assignment data may be used also to answer a different distributional question, one that asks how members of each of the organisational types are distributed across the various clusters or technology profiles. A number of the interesting patterns that emerge from the tables presented in Addendum A-II.3 should be noted here.

- Regional and Local Governments constitute almost half of the entire samples of organisations, and their distribution across the profile levels for networked applications is essentially the same as that for the entire population, with a third or more at the basic and advanced levels, and under a third at the intermediate profile level. The opposite pattern holds for the National Government organisations, which are concentrated (53.1%) at the intermediate profile level (TNA2). Relative to the population as a whole, the National Government organisations are concentrated at the intermediate and more advanced profile levels in regard to Network Service, and the Regional and Local Governments again display the same preponderance at the basic (TNS1) level as it found for entire ensemble.
- Clinics and Health Care units are relatively concentrated at the lower profiles for Networked Applications and Network Services, vis-à-vis the total population, whereas Hospitals and Laboratories are relatively concentrated at the intermediate profile levels for those dimensions. In this regard there appears to be a parallel between the Clinics and Health Care units and the Regional and Local Government organisations, on the one hand, and between Hospital and Laboratories and National Governments.

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<sup>20</sup> Even though they are slower in adopting the more advanced network services, regional and local governments during the pre-networking phase needed and may therefore have deployed wider array of applications software (vis-à-vis other organisations) which therefore were available to be networked.

Perhaps not surprisingly, a very similar pattern in the relative concentrations of the various types of public organisations appears also in regard to the intensity of intra-organisation deployment of networked applications. This may be seen from the statistics relating to the TNAD cluster assignments presented in the Addendum to Part II, Table A-II: 3.3 (Cluster Composition of Organisation Types).

### ***Meta-cluster analysis and organisations' overall technology profiles***

The broad patterns examined in the preceding paragraphs are brought out quite clearly by a "meta-cluster analysis" that has been conducted, further details of which are given in Addendum to Part II, Tables A-II:4.1 and 4.2. Our application of the cluster analysis in this procedure assigns each organisation to one or another of a distinct number of "technology profiles" (denoted TDMC1 through 5) which are associated with their respective constituent "cluster-assignments," and two other (binary) classifications that capture features of their network infrastructures and the range of business functions that are supported by their networked applications. This method of "data reduction" yields meta-clusters that have a natural rank-ordering by technology profile levels: TDMC1 and TDMC5 being the lowest and next lowest, while TDMC3 and TDMC2 are next-to-the top, and top-most on the scale, respectively.<sup>21</sup>

From the meta-cluster assignments yielded by this analysis it is evident that the larger organisations are systematically under-represented among those observed at the lowest level of these summary technology profiles. Thus, although organisation size may well be correlated with access to budgetary and technical resources that have advantageously affected the advance on the part of the large organisations, the results suggest that organisation size *per se* may not be exercising a separate, independent effect upon the rates at which these organisations are able to improve their performance.

The assignments of organisations produced by the meta-cluster analysis reaffirm the previous observations on differences in the relative concentration of organisations of different types at the various technology profile levels. Whereas regional government organisations are significantly concentrated at the lowest level, and local clinics and health care organisations tend to be clumped together at the level just above that, national government organisations and other entities in the health sector (particularly those dealing with health insurance) are present disproportionately at the highest level of the overall technology profiles. Hospital and laboratories, and other units of the government sector occupy intermediate positions among which the differences in the rank ordering technology profiles is not clear-cut. Whether the future will witness a tendency among the different types of public organisations toward technological convergence toward the upper end of the scale remains an open question. Their distinctive range of functions, however, makes it more likely that the substantial differences now present will persist for some time to come.

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<sup>21</sup> Addendum II, Table A-II:4, and Tables A-II.3 may be consulted for the basis on which these meta-cluster rankings rest.

## PART III

### THE IMPACT OF NETWORK TECHNOLOGY AND IMPLEMENTATION PRACTICES ON IMPROVEMENTS IN ORGANISATION PERFORMANCE

Are there robust positive relationships between the adoption and deployment of digital network technologies and quantifiable improvements in the performance of organisations in the public sector? If such effects do exist, how large are the impacts? Does the manner in which these technologies are used by the organisation to implement business processes also make any significant difference to the results, and if such is the case, which business process implementations merit identification as “best practices”? Are there answers to these questions that apply more or less uniformly to all public civilian organisational units, or does the functional nature of the agency, and the national setting make a difference? This part presents the findings of an initial, exploratory effort to address the foregoing important questions by focusing attention on the factors associated with improvements in two particular aspects of organisational performance: the average productivity of employees in dealing with the requests and needs of members of the public that contact the agency in question, and the organisation’s effectiveness in providing such services in ways that satisfy its citizen-clientele.

#### The Impact Measures Selected for Analysis

We begin by stating what should be understood by the term “productivity” in this context, and the bearing that this has on the selection of dependent variables for the purposes of the present analysis. Among the array of organisational performance metrics that are available in the NI 2004 dataset, those which correspond most closely to economists’ concept of productivity as an “efficiency” indicator -- an index representing the ratio between quantitative measures of the flow of outputs and inputs within the time span of a typical production cycle for the organisation in question.<sup>22</sup> Only three of the “metrics” for performance change that were collected by the NI 2004 survey of business decision managers fit that bill conceptually: *average time to resolution of client requests/needs*,<sup>23</sup> *average*

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<sup>22</sup> In the case of public service organisations, it is reasonable to ignore the substantial complications for practical productivity measurement that arise in the case of manufacturing and construction activities due to the accumulation and de-cumulation of inventories of work in progress and finished goods within arbitrary accounting periods, and variations in utilisation of fixed capacity due to cyclical fluctuations in the state of demand. We note that the set of metrics of interest here have been selected from among only one of those grouped under the broad heading of “productivity” by Douglas Frosst’s discussion of the four “productivity themes” of the Net Impact 2004 Report (p.42). See D. Frosst, “Net Impact 2004: From Connectivity to Productivity – European Public Sector,” October 2004 [available at [http://newsroom.cisco.com/dlls/tln/research\\_studies/pdf/net\\_impact,2004.pdf](http://newsroom.cisco.com/dlls/tln/research_studies/pdf/net_impact,2004.pdf).] The three other so-called “areas of productivity” in that Momentum Research Group’s NI 2004 *Report* are service volume, cost containment and revenue/fee growth. None of these relate outputs to inputs.

<sup>23</sup> If the time intervals involved are comparatively brief, it is reasonable to assume that for any given organisation a fixed number of employees would be involved in dealing with one such “case” during the period required for its’ resolution. That would support the interpretation of average time required as meaningful index of productivity. But the impact estimates available to us are not levels: as noted in the

*number of cases resolved per employee, and average cost per case resolved.*<sup>24</sup> Unfortunately, the latter member of this group could not be used, as suitable observations were available for only a very small number (12) of organisations -- far too few for the purposes of the planned statistical analysis.

Therefore the study reported here focused on “productivity impacts” of ICT infrastructures, network applications and the methods and extent of their implementation business was restricted to trying to account statistically for inter-organisation variations in the estimates of percentage change in average case resolution time (**metric 01**), and in the average number of cases resolved per employee (**metric 02**). The observations on this pair of dependent variables in the regression analysis exercises discussed in this Part, were derived from the BDM survey. More specifically, they are responses given by only those business decision managers who reported that their organisation actually *tracked the metric in question*, and then supplied a useable answer to the interviewers’ request: “estimate the percent impact, positive or negative, that your network applications have had in your business [sic] over the last twelve months.”<sup>25</sup>

In addition to the results obtained from the productivity impact studies, we present the findings of our effort to explain the pattern of variation in the estimates of the percentage changes in “*citizen satisfaction with your organisation*” that were supplied by business decision managers whose organisation tracked that dimension of performance (**metric 06**). It is worth pointing out that restricted as this focus on three metrics may be, it includes the two aspects of performance that garnered greatest votes from the business decision managers they were asked them to name which among a list of 12 metrics was the single most important metric for their organisation to track.<sup>26</sup> Citizen satisfaction (metric 06) was the winner, with 27.6 percent of the 210 usable responses; average time to case resolution came in second, with 21.9 percent. The average number of cases resolved per employee placed at the low end of the next most strongly rated group formed by three metrics whose shares in the total ranged between 7.6 and 9.0 percentage points.

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text, they refer to the estimated proportionate change in levels that occurred over the course of the preceding year. Unfortunately, that introduces an extra degree of ambiguity which renders the impact on “average resolution time” rather less appropriate than “cases resolved per employee” as an indicator of average productivity change.

<sup>24</sup> A fourth metric, *total cases resolved per day/week/month*, appears with these under the same “productivity theme” discussed by Frosst (2004), but it was excluded from this exploratory analysis on the grounds that percentage changes in this measure simply compounded the proportional change in the number of cases presented within the time interval with that in the average resolution time per case.

<sup>25</sup> Momentum, *NI 2004 Report* : Questionnaire B, Q.10.

<sup>26</sup> Momentum, *NI 2004 Report*, Questionnaire B, Q. 9a asked: “What is the single most important metric you track to determine the efficiency [sic] of your citizen services and support activities?” The wording may well have contributed to framing the consensus on metrics 06 and 01, and these responses thus should not be taken as indicating the relative importance attached to other aspects of organisational performance, such as task productivity and average cost per case. On the other hand, the relative number of organisations in our sample that reported tracking these metrics is positively correlated with their relative scores on the response Q.9a.



The observations upon which our statistical analyses focuses, however, are not the full set of available estimates that were obtained for the three variables in question from the 283 organisations represented in the business decision manager (BDM) dataset. In the first place, some of those observations had to be sacrificed if we were to be able to make use of the information about the immediate technological environment in which the business decision managers' impact estimates were framed. This reduced the eligible organisations to the subset comprised of 246 organisations whose responses to the TDM and BDM surveys could be matched, the subset that we will refer to as the BDMM sample.<sup>27</sup> Secondly, many more observations were discarded as a consequence of restricting our analysis to considering only those impact estimates provided by managers in the BDMM subset whose organisations actually tracked the metric in question. The numbers in the resulting (BDMMT) sub-sample dropped down to 60, 41, and 80 observations for metrics 01, 02 and 06, respectively.<sup>28</sup>

Our focus on the responses from organisations that tracked these metrics seems justifiable *a priori*, in view of the subjective source of the estimates, and it renders the results comparable with those found by the NI 2004 study – which similarly reported estimates pertaining to organisations that were tracking the metric in question.<sup>29</sup> But, there is no way actually to confirm the supposition that business decision managers were more accurate in estimating the changes that had occurred in each of these performance dimensions when they had had an opportunity to review objective data about their organisation's experience.

Some support for the latter view is provided by comparisons of the distributions of estimates from the tracking and non-tracking organisations, for

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<sup>27</sup> Table A-I:1 (in Addendum to Part I) compares with gross composition of the BDMM sample with that of the TDM sample, with respect to geographic region, size and some technical features of the organisations' networks. The distributions of the organisations forming the "matched" sample, in these broad dimensions, closely resemble those shown in the same table for the much larger TDM sample.

<sup>28</sup> It is regrettable that the sample of observations remaining for analysis is so small for the most conventional among the pair of productivity impact variables. The temptation to relax the restriction that the estimates be those from organisations that tracked the metric has been resisted, on two grounds. First, for the purposes of this exploratory study it was desirable to maintain the same data reliability criterion as that imposed by the Momentum Research Group in their statistical analysis. Secondly, comparisons of the statistical distributions of responses from organisations in the full BDM sample revealed rather complicated patterns of differences between those that tracked and those that did not, making it difficult to characterise the overall nature of managers' perception biases. This was especially so for the percentage changes in the average number of case resolutions per employee: the mean percentage change estimates for the two groups coincided closely at c. 33.4 and 34.6, whereas median for trackers was 40 vs. 30 for non-trackers; at the same time, the range of estimates in the latter group was more compact and shifted toward the extreme upper end vis-à-vis the range among the trackers. Some analysis of this issue obviously is indicated for future work, but its success will turn on finding instrumental variables that can control for differences in tracking policies and, at the same time, not be correlates of network infrastructure and applications deployment, or of information management practices. In addition, as may be seen from the plots of the cumulative distribution of responses in Addendum to Part III (Figure A-III:1), the "non-tracking" estimates include suspiciously large *negative* entries.

<sup>29</sup> See Frosst (2004), quoted in the text below.

these do exhibit a quite pervasive pattern of divergence. In almost every instance the mean and median estimate from the non-tracking organisations lies below the corresponding statistic calculated from the distribution of estimates from tracking organisations.<sup>30</sup> This tendency is revealed by a more detailed comparison of the entire distribution in each of the three metrics upon which our analysis focuses: lower estimates of the magnitude of improvements, and larger estimates of adverse performance results, are more frequent among non-trackers.<sup>31</sup> In the case of changes in case resolution time (Metric 01) responses in the positive change range tend to be lower for organisations that did not track. This comparative bias downwards appears throughout the entire range of estimates of the “impact” on client and customer satisfaction with the organisation (Metric 06). A more complicated picture is found in regard to the less ambiguous productivity change indicator, pertaining to the number of cases resolved per employee (Metric 02): the distribution of estimates from organisations that were not tracking the metric are biased downwards in the low positive range, but upwards at the high end, because the estimates from the tracking organisations are bunched in the range around 50 percent gain.

These observations should be borne in mind when considering the results of the analysis reported here: they pertain to a sub-sample of organisations (the BDMMT sub-set) that tended to supply higher estimates of performance gains.

### **Statistical Modelling Approach and Implementation**

The statistical modeling approach adopted is thoroughly straightforward, as it reflects a deliberate effort to keep the econometric methodology and its results as simple, transparent, and easy to interpret as was possible. Towards that end we chose to model the effects upon each “impact” metric of an organisation being in one or another of the categorical “states” defined by a multi-dimensional space. In that space we are able to describe the organisation’s state, or “categorical location” with reference to arrays of (a) fixed characteristics, (b) technology adoption and deployment profiles, and (c) business process and managerial implementation practices.

By using OLS regression analysis with dummy variables<sup>32</sup> to represent the categories in each of those dimensions (including dummy variables to allow for interactions among the different dimensions), one can in this manner obtain estimates of orthogonal “effects” differences between states upon the dependent impact variables. The latter estimates are readily added up to assess the magnitude

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<sup>30</sup> Addendum Table A-III:1 presents the mean, median and ranges of the estimated percentage changes for all 13 performance metrics, calculated from the full set of (283) organisations in the BDM sample.

<sup>31</sup> This may be seen from the panels of Figure A-III:1 in the Addendum to Part III.

<sup>32</sup> In this case, with no continuous variables among the regressions, OLS estimation is equivalent to analysis of variance. The appropriate tests of the overall significance of the estimated model therefore are presented as the standard ANOVA F-tests of significance, but the usual t-tests of statistical significance are obtained for the coefficient estimated for each of the (dummy variable) regressors.

of combined performance improvement effects that are systematically associated with differences among organisations in the state space described by the model.

To implement this statistical approach we obtain categorical variables referring to dimensions (a) and (b), above, by drawing directly upon the results of the preceding descriptive analysis. For the fixed characteristics, therefore, we used the classifications of organisations according to function/type, employment size, and country/region in which they are located (see Addendum to Part I, Table A-I: 1).

Next, to characterize the organisations' technology adoption and deployment profiles, we have made use of the results of the cluster analyses described in Part II, which assigned all the organisations that comprise the TDM dataset to:

- Clusters (NS1, NS2 and NS3) on the basis of the services available on the organisation's network;
- Clusters (NA1, NA2, and NA3) on the basis of the network applications available to the organisation's personnel;
- Clusters (NAD1, NAD2 and NAD3) on the basis of whether or not the proportion of their employees to whom their network applications had been deployed exceeded the median extent of deployment in the entire population sample.

In addition, we are able to make use of an organisation's assignment to one or another of the "meta-clusters" (TDMC1 through 5) that were constructed on the basis of the triplet of cluster assignments just listed, and two other dichotomous variables. The latter pair of dummy variables capture whether the organisation is or is not WAN-connected, and indicate whether more than half of an array of organisational functions are supported by networked applications. The resulting meta-cluster assignments provide a parsimonious way to categorize the organisations according to their patterns of technology adoption and deployment, while allowing for the complementarities and interactions among the specific underlying technological profiles that give rise to certain distinctive "family resemblances" among the organisations' overall ICT technology profiles. This procedure, which is described more fully in the addendum to Part III, allowed us to formulate and estimate a sequence of three, progressively more detailed "basic" regression models to account for the variations in the impact estimates for each metric.

In the next step, the "basic model" for each of the three metrics – comprised of the candidate regressors representing the fixed characteristics and current technological profiles – was "extended" by the introduction of selected arrays of regressors (again, dummy variables) representing more qualitative but potentially no less relevant factors affecting payoffs from investments in network infrastructure and networked technologies. These variables represent the presence or absence of certain business process implementation practices, as well as managerial practices and features of an organisation's culture that affect its acquisition and utilisation of networked information technologies.

For each metric we investigated a particular set of such practices among which are those identified by the *NI 2004 Report* (Figure 62, p. 43) as the most salient candidates for designation as “best practices.”<sup>33</sup> One source of these variables is the responses of the business decision managers to the Survey questions relating to seven practices that were grouped under the heading “Business Process” and “Organisational Culture and Behaviour.” Frosst’s (2004) discussion of the findings suggests a number of additional “best practices,” identifying particular items among them as being pertinent for significant improvements in the three performance metrics of interest.<sup>34</sup> The resulting set of candidate “best practices” on which we focus thus included six additional dichotomous variables that were constructed from the responses of technology decision managers in the organisations constituting the BDMMT dataset. The full list of thirteen candidate “best practices” is presented in Addendum Table A-III.2.

The definitions of these dichotomous variables, along with the sources in the BDMMT data set (indicated by the NI 2004 questionnaire numbers and codes) appear in the three “boxes” that form Addendum Table A-III.3. For each of the three metrics that we take to be the dependent variable of our regression models, the corresponding box shows a selected array of practices involving business processes and organisational culture and managerial behaviours. They are the ones that have been cited as “best practices,” having been found by the *Net Impact 2004* study to be systematically associated with improvements in the specific performance metric to which the particular box relates. We note that Frosst’s (2004) feature article *Net Impact 2004: From Connectivity to Productivity*, helpfully reveals the criterion used by the Momentum Research Group to identify the “best practices” cited in their Report:

“A corporate action was identified as a best practice if it has a strong (statistically significant), predictive relationship with one of the 12 metrics [of organisation performance that were] tracked.”

But, it is not the purpose here to uncover the precise statistical procedures that led to the list of “best practices” identified by previous studies of the NI 2004 Survey data.<sup>35</sup> The main interest in the present study, instead, is to discover whether or not within the context of the different modelling framework that has been described, any among those practices appear as factors significantly associated with estimated rates of improvement in organisational performance.

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<sup>33</sup> Figure 62 of the *NI 2004 Report* refers to so-called “Best Practices” that are pertinent to improvements in 5 metrics collectively labeled “Efficiency Outcomes,” among which our three (M01, M02 and M06) are included. Additional “best practices” are identified in the same Figure, under the headings “Applications,” and “Networking Technologies,” but our framework subsumes investigation of the effects of many of these in assessing the significance of variations among the organisations’ technology profiles.

<sup>34</sup> Frosst (2004), Appendix A. See [http://newsroom.cisco.com/dlls/tln/research\\_studies/nis\\_2004.html](http://newsroom.cisco.com/dlls/tln/research_studies/nis_2004.html).

<sup>35</sup> The NI 2004 Report itself is not forthcoming about the statistical procedures that were employed to obtain these or other results, such as the estimated percentage improvements in the different metrics with which identified sets of “best practices” are said to be associated. But, if discovering that were of prime interest, we have every reason to suppose that the Momentum Research Groups would have been as forthcoming in replying to questions that we might have asked about the econometrics, as we have found them to be in responding to requests about the matters relating to the dataset.

## Overview of the Regression Analysis Procedures

The statistical estimation results we have obtained are readily summarized and interpreted. They are set out and discussed below without entering into a close examination of the quantitative details that are presented in the three panels of Table III-1. We defer to the Addendum to this Part a more detailed description of the sequential the statistical procedure that led to the estimated equation for each of the three metrics. Starting with explanatory variables indicated by the full modelling framework that has been already described, a step-wise examination was conducted of the effects of organisational characteristics, the technology profiles indicated by the meta-cluster assignment of the organisation (based on the analysis of the full TDM sample), successively dropping variables that were not statistically significant from the regression equation before introducing dummy variable for the complete list of “best practices” shown below in Table III-2.

In the case of each regression model the specified list of “best practices” for e-network technology managers followed the list identified in the Momentum Research Group’s *Net Impact 2004* study as being specifically relevant for attaining high rates of improvement in that particular performance metric. These lists are presented in the three parts of Addendum Table A-III:3, where the sources of the data in the NI 2004 survey questionnaire data for each are indicated. From this step we obtained a “reduced extended model” that retained only those regressors that were found to be statistically significant at or below the 5 percent level. The latter regression model dummy variables were then introduced, to control for effects of organisation type (government vs. health) and residual effects of national differences in public organisations operations – and their interactions with the technological control variables. From that step we obtained a final “reduced” model, by retaining only the variables that survived as statistically significant. The resulting estimates for the three regression models estimates are presented in the three panels of Addendum Table A-III:2.

From the notes to Addendum Table A-III: 2 it will be seen that the dependent variables in the estimated models are in each case the natural logarithmic transforms of the business decision managers’ estimates of the percentage change in the performance metric. Working with this transformation of the dependent variable is a standard analysis of variance procedure that allows the explanatory factors to have multiplicative effects upon the dependent variable. It is a simple matter to recover the predicted percentage impacts that the models imply for organisations belonging to the indicated categories.<sup>36</sup> To the examination of those results (shown in Table III-1), and discussion of their interpretation we now may turn.

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<sup>36</sup> This is done by finding the anti-logarithm of the estimated coefficients of the categorical (“dummy”) variable, and, where appropriate, sums of dummy variables shown in the regression equations of Table III-3. It should be noted that since the categories are exhaustive in each of the nationality, organisation type, and meta-cluster dimensions, the constant in the regression model represents the estimated mean impact on the dependent variable for organisations that belong in categories not explicitly specified by the equation’s explanatory variables.

## Discussion and Interpretation of the “Impact” Findings

The following discussion is focused upon four salient aspects of our findings in Table III-1, pertaining to the effects upon the percentage rate of improvement in performance attributable to

- (1) differences in the networked technology “profiles”;
- (2) differences in “best practices” in deployment and utilisation of the new technologies;
- (3) the presence of particular combinations of technology adoption and “best practice” approaches to their implementation and application;
- (4) national differences vs. differences between government and health-sector organisations.

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**TABLE III- 1**  
Technology and Implementation Practice Impacts  
on Perceived Improvements in Tracked Performance Metrics

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**Panel 1. Improvement in Average Time to Resolve Citizen Requests/Needs**

Estimated impacts	Best Practice Implementations	
	Significant Best Practices:	
On M01—for Organisations in category:	None	INTEGRBP
<b>Technology Meta-Clusters : All</b>		
<b>All Government and Health Organisations</b>		
<b>Countries:</b>		
<b>UK, Holland, Italy and France</b>	<b>42.6 %</b>	<b>75.4%</b>
<b>Germany</b>	<b>20.3 %</b>	<b>35.9 %</b>
<b>Sweden</b>	<b>19.1 %</b>	<b>33.8 %</b>

**Note:** These effects were calculated from the coefficients of regression LNImp01T-F2, estimated from a restricted version of model LNImp01T-F from which variables not significant at the 10% level were excluded. Effects for SPAIN, and POLAND could not be estimated (automatically excluded) with the latter model.

**Source:** Calculated by taking anti-logs of the sums of the relevant regression coefficient estimates in Table A-III:2.

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Table III – 1, continued

**Panel 2. Percentage Improvement in Number of Cases Resolved per Employee**

Estimated impacts	<u>“Best Practice” Implementations</u>	
	None	<u>Significant Best Practices:</u> INTEGRBP
On M02 -- for Organisations in category :		
All Countries (excluding UK, Spain)		
Technology Meta-Cluster: All ex.TDMC3		
Government	43.7 %	.... *
Health	26.5 %	.... *
Technology Meta-Cluster:TDMC3		
Government	15.8 %	81.5 %
Health	9.6 %	49.4 %

**Note:** These effects were calculated from the coefficients of regression LNImp01T-F2, estimated from a restricted version of model LNImp02T-F from which variables not significant at the 10% level were excluded. Effects for SPAIN, and the UK could not be estimated (automatically excluded) with the latter model.

\* Not significant except for organisations classified in TDMC3 meta-cluster.

**3. Improvement in Average Customer and Citizen Satisfaction**

Estimated impacts	<u>Government and Health Organisations in:</u>	
	<u>All Countries ex.</u> Germany	Germany
On M06--for Organisations in category:		
Technology Meta-Cluster:		
All, excluding TDMC5		
Without Best Practice Implementations	43.5 %	14.0 %
With Significant Best Practice: INTEGRBP	60.8 %	19.6 %
Technology Meta-Cluster:		
TDMC5		
Without Best Practice Implementations	25.4 %	8.2 %
With Significant Best Practice INTEGRBP	35.5 %	11.4 %
CTRSTRAT	51.9 %	16.7 %
INTEGRBP & CTRSTRAT	124.2 %	23.4 %

**Note:** These effects were calculated from the coefficients of regression LNImp06T-F2, estimated from a restricted version of model LNImp06T-F from which variables not significant at the 10% level were excluded.

**Source:** Calculated by taking anti-logs of the sums of the relevant regression coefficient estimates in Table III-2.

**Table III-2**

**“Best Practices” Tested for Statistical Association with Estimated Rates of Improvement in Public Organisation Performance**

Metrics: Average Employee Productivity, speed (M01) and volume (M02) of case resolution, and Client and Customer Satisfaction (M06)

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**Business Process**

- **Data mining and Analysis Supported by Network Wide Applications (DATAMIN)**
- **Case management Internet Connected (CASEMNGT)**
- **Service Delivery Internet Connected (SERVDEL)**
- **Business Process Automation: Case Management (AUTOBPCM)**
- **Business Process Automation: Service Delivery (AUTOBPSD)**
- **Automating Workforce Collaboration and Training (AUTOWKTR)**
- **Problem Diagnosis and Resolution (PROBDIAG)**
- ***Business Process Integration (INTEGRBP)***

**Organisational Culture and Behaviour**

- **Technology enabled services uniformly deployed organisation wide ORGWIDE)**
  - **Re-engineered business processes before implementing new network applications (PREREENG)**
  - **Re-engineered business process in response to implementing new network applications (REENGINEER\_WITH)**
  - **IT Department works closely with organisation leaders (ITDEPCOO)**
  - ***Organisational strategic IT Plan communicated throughout the organisation (CTRSTRAT)***
-



**1) Differences in technology profiles do matter, but fine grain details distinguishing the variety of these organisations' existing network infrastructures and networked applications are not found to make a substantial difference.** The main significant difference is that between the organisations in the category characterized by a minimal overall technology profile (TDMC1), on the one hand, and on the other hand those organisations that have internal and external web portals and that are farthest along toward having the complete array of networked applications.

One may be surprised by the result that organisations that attain the more advanced overall technology profiles (TDMC4, or TDMC5 or TDMC3, ranking them in ascending order) report significantly smaller rates of improvement in productivity performance (M02), and in citizen satisfaction (M06) than those that have attained just a minimal overall profile (TDMC1, the default dummy which is absorbed by the constant in these regressions). But, this finding really is not counter-intuitive. Indeed it is readily interpretable as reflecting either of two quite plausible conditions or indeed both of them.

**(a) The performance improvement payoffs in terms of the rate of increase number of cases resolved per employee, and improved customer and citizen satisfaction, may well be subject to diminishing returns to further technology acquisition.** Organisations we observe as having only attained the minimal levels of network infrastructure and networked applications therefore would have experienced (and so would report) bigger percentage gains during the preceding year than would be the case for their counterparts whose technology profile had been advanced beyond that basic level during the same time interval.<sup>37</sup>

**(b) Our results also are quite consistent with the possibility that business decision managers in organisations that are still at low levels in terms of digital networked technology adoption/deployment tend to over-estimate the pure, technology-driven effects on performance of having become "Internet-connected"** -- that is, of affording clients and customers online access, and providing employees with virus-free email, and on-line back-office applications for managing accounting and finance, and human resource management and training. If there are positive "Hawthorne effects" from induced changes in employee motivation and morale associated with altered working conditions, equipment and managerial attention, those are likely to be strongest during the initial introduction phase. Typically Hawthorne effects on worker productivity are found to wear off with the passage of time, unless renewed by

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<sup>37</sup> Why it turns out that improvements in average time for case resolution (metric Mo1) are not significantly associated with variations in technology profiles is not immediately apparent. But this finding does tend to reinforce our previously expressed doubts about the suitability of this variable as a productivity measure. On the other hand, it is possible that each successive rise in the organisation's network technology profile does bring quicker "resolution of cases." But that possibility just raises the difficult issues that Part I raised about what faster "resolution" actually means in terms of actual provision of services that satisfy clients' requests.

recurring major changes.<sup>38</sup> It is not implausible to conjecture that a similar attenuation of client/customer expressions of satisfaction occurs, with the fading of the sheer novelty element of the organisation's website for users who become accustomed to accessing its online services.<sup>39</sup>

**(c) But, it remains possible that misleadingly high estimates of the recent pace of performance improvements are offered by business decision managers that have had the responsibility for recently introducing network connectivity in their organisation.** While we cannot tell that the organisations that are observed to be at an early stages in their use of network services and networked applications have only recently arrived there, this is not unlikely, and the managers involved may therefore be particularly concerned to encourage the allocation of resources that would enable continuation of the process, by announcing overly enthusiastic estimates of the performance gains that accompanied the initial steps of the process. Indeed, even if the commitment of the organisation to further investments in rolling out network services and applications appeared to have "stalled" for some time, managers seeking to re-invigorate the process might be disposed to "accentuate the positive" when estimating recent changes in productivity and client satisfaction. The shadow of ambiguity that is thus cast over our findings would seem to be an inevitable consequence of having to work with subjective, rather than objectively grounded estimates of the pace of changes in organisational performance metrics.

**2) Some among the identified "best practices" are found to matter quite a lot, but most of the candidates examined statistically simply do not significantly affect the impact measures.** In the final regression models at which we have arrived, at most only 3 of the 13 supposedly significant "best practices" that the *NI 2004 Report* cited in the case of customer and citizen satisfaction (listed in Addendum Table A-III.2) are found to be statistically significant in positively affecting the improvements reported by organisations tracking that metric. In the case of the productivity measure, none among the 8 practices identified are significant. Only one practice, "integration of business

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<sup>38</sup> On "Hawthorne effects" well known in industrial psychology, see, e.g., R.Gillespie, *Manufacturing Knowledge: a History of the Hawthorne Experiments*, Cambridge: Cambridge University Press, 1991; H. M. Parsons (1974) "What happened at Hawthorne?" *Science* vol.183, 922-932, provides a compact but detailed description of the experiments at the Western Electric Co.'s plant in Hawthorne, N.Y., using these to support the interpretation of the effect on individual performance as the result of feedback-promoted learning. If one accepts the experiential "learning" hypothesis, the implication is that while the effect is not transient, the performance gains are strongest along the earliest portion of the learning curve.

<sup>39</sup> West's (2005) review of assessments of e-government based on analysis of the contents of government websites, and his own extensive content analysis study, does not report research on user-satisfaction assessments. But it seems pertinent here to notice the finding (based on a very large number of U.S. federal and state websites in the years 2000 through 2003) that "most sites incorporate contact and content in an incremental fashion, with few big changes over the four-year period." (p.48.) This suggests that if customers care about the changing features of these sites, the big impact would come at the outset where the novelty of the affordance was most discernable.

processes"<sup>40</sup> is found to have a statistically significant positive effect on the speed with which client requests are resolved. Indeed, this practice appears to be truly "best." in its pervasive positive association with increased performance in all of the three metrics.

**3) The regression analysis findings point clearly to the existence of generally higher payoffs – in terms of rates of performance improvement -- when public sector organisations at higher technology profile levels also adopt certain "best practices" in technology management.**<sup>41</sup> Although it was not the intention to confront the predicted impact estimates presented by the Momentum Research Group's NI 2004 study for these three metrics with results from this analysis, one cannot help but be struck by the marked differences between the two in regard to the magnitude of the resulting impact effects.

There is a reasonably close concurrence between the Momentum Research Group's estimates of a 45-65 percentage point annual rate of gain in citizen satisfaction and the range of the effects on that metric that are shown for the various organisational categories in Table III-1 (panel 3). For the other metrics, however, the differences are very pronounced. Whereas the estimated impacts in the range 20-45% are reported by the *NI 2004 Report* for improvements in average time to case resolution when "best practices" are followed, the corresponding entries presented by Table III-1 (panel 1) show almost the same range of impacts *when none of the business process and organisation management practices are present*. This result applies across the several country groups shown. Moreover, where there is "integration of the business process" with network services and applications the range of impacts is seen to increase by a factor of more than three-quarters.

A similarly startling disparity is found in regard to the estimated impacts on the most reliable productivity metric, the average number of cases resolved per employee: whereas the Momentum Group indicated 10-20 percentage point annual productivity gains under 'best practice' conditions, approximately the same range (9.6-15.8%) of effects is estimated for organisations in meta-cluster TDMC3 -- when they are using none among the list of "best practices." (This may be seen from the range between the estimates for organisation in the Health and the Government categories in Table III-1, panel 2). It might be inferred that in this case more advanced technology is substitutable for business process integration and other recommended "best practices," because in contrast to organisations that only attained the lowest technology profile (TDMC1), organisations belonging to meta-cluster TDMC3 were technologically far advanced: they deployed internal and external web portals, as well as more than the minimum profile of networked

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<sup>40</sup> Defined by Momentum, *NI 2004* Questionnaire B: Q.15b as entailing consistently aligning the organisation's business process, network applications and network infrastructure.

<sup>41</sup> See Momentum, *NI 2004*, Appendix 4, pp. 45-46 for estimated impacts associated with all forms of "best practice". Because it would appear that a mélange of advanced and commonplace network applications and infrastructure technologies are associated with these estimates, along with the business process and organisational culture and (managerial) behaviours, it is difficult to directly compare those estimates with the predicted impacts obtained from our analysis in Table III-1.

applications (finance and accounting, and human resources management and training); and had achieved an above-median extent of deployment of customer or citizen relationship management applications on their network.<sup>42</sup>

What is more impressive, indeed truly striking, is that organisations which attained that more advanced (TDMC3) technology profile and also undertook the organisational changes needed to integrate their business processes with their networked information facilities, reported much bigger annual gains in average productivity. The estimated rates averaged roughly twice those experienced by organisations (in the corresponding Health and Government sectors) that had just reached the first step on the scale of technology profiles. Moreover, the additional presence of this particular “business practice” is associated with a more than four-fold increase of the average annual rate of growth in cases resolved per employee, producing spectacularly average high growth for the entire range of organisational types and countries (as may be seen from Panel 2 of Table III-1).

**4) Inter-country variations in manager’s estimates of performance payoffs from ICT investments generally are not found to be statistically significant *where any of the other explanatory factors are present.*** Despite the emphasis placed on national differences by the presentation of finding in the NI 2004 Report, our results do not show significant inter-country differences in productivity impact measure M02 (growth rate of cases resolved per employee). For the customer and citizen satisfaction metric we find only that in Germany the range of improvement estimates is markedly lower among both the government and health organisations. The other improvement metric for which country effects are significant is the average speed of case resolution (M01): there both Germany and Sweden exhibit significantly smaller improvement percentages than the rest, and France stands out with significantly higher improvement percentages vis-à-vis Italy, Holland and France – the three countries not being statistically distinguished by the estimates.

Inasmuch as Sweden and Germany (along with the UK, whose effect could not be estimated in this model due to multi-collinearities) appear among the leaders of the 8-country group in regard to measures of the extent of diffusion of digital network technologies, one may be tempted to suggest that here the influence of diminishing marginal returns to investments in infrastructures and network applications is once again showing its hand. Were that to be the case, should we not expect to find signs of diminishing marginal returns being reflected in a significant negative association between this metric (M01) and the level of these organisations’ overall technology profiles? Yet, Panel 1 of Table III-1 reports that the meta-cluster classification variables show no such significant differential effects, and therefore drop out of the final estimates of the regression model.

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<sup>42</sup> Accordingly, as noted above in point 2, the range of impacts found for government and health organisations in the lower technology meta-cluster (TDMC1) and using none of the “best practices” are considerably higher, running almost three times larger than the corresponding TDMC3 estimates.

Two points may be pertinent in understanding this puzzling result. First, it should be remarked that the findings presented in Table III-1 for M01 (like those for M02) were obtained in the final stage of a procedure that first estimated the “extended” regression model – in which the vector of 7 “best practice” variables listed in Addendum Table A-III-3 was added to the regressors of a “basic” model consisting of the 5 meta-cluster variables describing the technology profiles of these organisations. In the resulting estimated model for resolution time (M01) it was found that in addition to business process integration, the presence of network wide applications supporting data-mining and analysis and an interaction between the latter and the technology profile described by meta-cluster TMC4, also had significant positive effects on the reported improvements in performance.<sup>43</sup> Then, starting from a reduced model with just those (significant) explanatory variables, the final step of our procedure introduced (dummy) variables for organisation type (government and health) and nationality—in order to see whether those might account for any of the residual variance. The outcome was that while there were no significant effects of organisation type, the national differences that appear in Table III-1 (panel 1) displaced TMC4 along with data-mining (and the interaction between them) from the list of significant explanatory variables, and hence from the final regression estimates.

What this would seem to suggest is the presence of a latent correlation between the indicated pattern national differences and the extent of the array of network services that have been introduced by these organisations. It was remarked earlier (in the discussion in Part II) that organisations in the technologically leading countries in the northern European region, and particularly the larger among the public government and health organisations are prominently represented in the more advanced technology meta-clusters. Although the effects of the latter evidently are not systematically big enough to support the diminishing returns explanation, it may well be the case that the simple device of meta-clustering cannot adequately capture some important features of technological difference that exists among the organisations which track the speed of case resolution, and that those latent features happen to be correlated with national/regional differences.

Support for this suspicion may be found in a second observation: on average the public organisations in Sweden and Germany (along with those in the U.K.) score very high in the ranking of the surveyed countries according to the mean number of organisational functions (among 13 identified) that are being supported by network wide applications in the country’s public sector organisations. By contrast, France scores far lower in the rankings on the same criteria, coming closest to Poland in the bottom position. That particular variable for individual organisations, however, was not used (either explicitly or implicitly) among the regressors in the basic model for M01, but it may prove in future work to be an important explanatory variable. If the indicated inter-country difference in its mean

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<sup>43</sup> Inasmuch as a feature of the TMC4 technology profile is that the network services cluster of the organisation is centered on TNS3, which represents organisations that have the complete array of 11 network services in operation, the existent of a strong positive interaction effect with network wide services supporting data-mining and analysis is quite understandable.

value was statistically significant, the introduction nationality “controls” could be responsible for displacing all the meta-cluster variables from the statistical explanation of the variance in this metric. That conjecture at least suggests an avenue deserving further exploration by means of multivariate regression analysis.

### **A CAUTIONARY CONCLUSION: THE PROBLEM OF SELECTION BIAS, AND THE WAY FORWARD**

The meaning of the foregoing results should be interpreted with some caution, especially in regard to inferences regarding the effects of adopting particular configurations of e-network technologies and implementing these in conjunction with specific business practices. It has been quite straightforward to present the findings of our regression analysis using categorical explanatory variables as a conventional analysis of variance, in which the estimated coefficients are the means of the respective “treatment effects,” e.g., the “treatments” being the acquisition of the indicated technology profile (meta-cluster) with or without accompanying organisational practices such as a particular business process automation, or integration with networked applications. Nevertheless, it must be borne in mind that the estimated effects tell us about the “average treatment of the treated,” and not what could be expected were those same “treatments” to be applied to the organisations that had not acquired a particular technology, or had not modified their business practices to better adapt the processes to their existing networked technologies.

The generic problem to which this points is “selection bias.” But here it takes a form that is distinct from the broader issues of sample selection that are discussed in the Addendum to Part I, and which have a more immediate bearing upon the findings in Part II. Attention was directed in that connection to the problem of extrapolating the findings about the technology adoption and implementation patterns among the “connected organisations” (comprising the TDM sample) to the population of public sector organisations that were ineligible for inclusion, either because they were too small or because at the time they did not have even a single active service carrying Internet traffic on their networks. This problem, in addition to the illegitimacy of inferring dynamic processes from cross-section relationships, was acknowledged among the reasons for caution in reading the cluster analysis findings in Part II as offering conclusive support for the hypothesis that public sector organisations generally follow a path of incremental network technology adoption leading from basic to more and more advanced “technology profiles.” Thus, organisations of the kind that were still not “connected” at the time of the survey could turn out to exhibit patterns of cross-section differences (as well as dynamic behaviours) that were quite different from the experiences of the TDM sample population.

Similarly, in the study of effects on organisational performance based upon data from the matched business decision managers’ survey responses, and, more restrictively, upon the responses from those organisations that had tracked our selected performance metrics, it is not legitimate to simply extrapolate the results

to the larger population of “connected organisations.” Even though the BDMM sample composition quite closely resembles the TDM in its gross features (as has been noted from the sample comparisons in Table Addendum A-I:1), that finding does not suffice to eliminate the possibility that organisations whose business decision managers were willing to respond to the second survey also possessed certain capabilities and managerial practices that distinguished them from the rest of the population; features which tended to augment the positive effects of the treatments identified by our regression model.<sup>44</sup> This holds *a fortiori* for the organisations in the BDMM sample that tracked the performance metrics – the selected subgroup upon which the analysis of Part III has focussed.

Indeed, one must press the point further: to the degree that the information technology facilities and implementation practices of these organisations can be regarded to be endogenously determined, which is to say that their choices reflect the outcome of a balancing of projected benefits and costs entailed in technological and organisational adoption and adaptation. It is then reasonable to suppose that the units which had undertaken greater investments in technical and organisational change were different from the others in some ways that their technical and managerial decision makers perceived to favor a greater net payoff in terms of organisational efficiency or effectiveness. Unidentified factors that were associated with the acquisition of more advanced network services and networked applications, and with the re-engineering of business processes that complemented the acquisition of those technological facilities, therefore may have contributed to the estimated “treatment effects”. The magnitudes of treatment-specific performance improvements that have been presented here would thus tend to over-state the gains to be expected were the same investments to be undertaken by organisations that share the attributes of the “un-treated” members of the population.

These cautionary comments carry a two-fold message. One thread is plain enough: the findings reported should be read as descriptive of what has occurred, and not as counterfactual propositions about what would have occurred, or could be expected to occur in some other past or future states of the world. The second thread leads toward a better appreciation of the need for further research. Understanding the determinants of the technology adoption and business process adaptation decisions of these organisations would, of course, be of value in its own right, but carrying out such a study also would contribute to identifying otherwise latent inter-organisational differences in conditions that should be controlled for when estimating the “treatment effects” associated with technology adoption and related reconfigurations of business processes. While that undoubtedly is a feasible step that is well worth taking with the data from the TDM survey that is presently available, it will not suffice to dispose of the selection bias problem. The reason is that it cannot carry the analysis of the effects of heterogeneity among the

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<sup>44</sup> For an overview of “treatment effects,” the economic importance of selection bias for policy conclusions, and modern econometric methods of dealing with the problem, see J. J. Heckman, “Varieties of selection bias,” *American Economic Review*, 80(2), 1990:pp. 313-318; J. Heckman, R. Lalonde and J. Smith, “The economics and econometrics of active labor market policies,” in *The Handbook of Labor Economics*, O. Ashenfelter and D. Card, eds., Amsterdam: North Holland, 1999.

organisations farther than the limitations of the observations provided by the cross-section data captured by the NI 2004 survey.

To take that further step, we would need to deal with the existence of residual unobserved heterogeneities among organisations that may have affected the performance impacts associated with specific technology adoption and implementation investments. What is called for here is a repeat of the Net Impact survey conducted by the Momentum Research Group, which would permit the creation of “panel” versions of the TDM and BDMM datasets. That would, of course, be of value in providing a more precise view of the trends in diffusion and business practices among public sector organisations. Yet, its significance in the context of the present discussion is that a second round of observations on a sub-sample of the NI 2004 organisations would make it possible to study the inter-period differences in treatment effects. That would provide a straightforward and robust means of controlling for unobserved heterogeneities that took the form of “fixed effects” upon the rate of improvement in organisational performance deriving from network technology-related investments.



## **ADDENDA**

### **Digital Information Network Technologies, Organisational Performance and Productivity**

By

**Alexandre Caldas, Paul A. David and Orges Ormanidhi**

20 December 2005

#### **ADDENDUM TO PART I**

##### **A-I.1 The Momentum NI 2004 Survey: a significant empirical resource**

###### ***The nature, coverage and scope of the survey data***

The Momentum Research Group's Report, *Net Impact 2004* sought "to evaluate the productivity relationships that exists [sic] between applications, networking infra-structure, business processes and other organisational behaviors within the respondent organisations from the European public sector." The two datasets that were created for that study represent a significant empirical resource, one that permits us to tackle the foregoing "big" questions, and to investigate many other more specific issues about public sector organisations' acquisition and use of IT. As will be seen, the one area in which investigations remain severely data-constrained concerns objective measures of productivity -- the conclusions offered by the Momentum Report regarding impacts upon "productivity" and "efficiency" notwithstanding. But the underlying data source is in other respects remarkably rich and detailed, and so opens up many related avenues for statistical investigation.

The data to which we have been given access resulted from 1,112 structured telephone interviews with information technology officers ("technology decision-makers", TDM), and 283 similar interviews with "business decision-makers" (BDM) in European public sector organisations. The interviews were conducted during the period between early November 2003 and late January of 2004 by contacting government and non-profit healthcare institutions in eight countries (France, Germany, Italy, the Netherlands, Poland, Spain, Sweden and the United Kingdom) and collecting information from those that satisfied certain "screening criteria." The latter were designed to filter out very small organisations and those that were not currently "network connected" -- in the sense of not having at least one networked application carrying live data and information to or from an external network server.

The entities entering the Momentum study were not a random sample of European public sector organisations. Some 2600 organisations, among the 32,000 organisations listed in Dun and Bradstreet's database of European businesses that were contacted, agreed to cooperate. Those selected were the first 1129 to meet the study criteria: being in the defined sector, employing more than 25 persons, and having deployed at least one networked information technology application. The 1,112 were those who completed the first set of interviews (with IT decision-makers having responsibilities for network hardware and applications procurement and related matters). Contact information was obtained from the "IT decision-makers" to select a smaller number of "business decision-makers" from these

organisations, but the exact procedure for selection is not known. It appears that a uniform target sample size of 40 was set initially for each country, but in the implementation a smaller number of interviews were conducted, especially with personnel from organisations in Poland.

Although Momentum Research appear to have analysed the two bodies of observations yielded by these interviews separately, and bring their findings from each together in its 2004 report *Net Impact: From Connectivity to Productivity* [NI 2004], the files at our disposal make it possible to create a unified, or merged dataset containing all the information collected for a sub-group of some 280 organisations that are distributed fairly uniformly among the eight European countries. Consequently, we have the opportunity not only to study the latter sub-group of organisations' IT adoption and implementation experiences, and the associated perceptions and expectations of the managers involved, but we can establish the degree to which they are representative of the much larger sample of "connected" public sector organizations in Europe. This will be important in correcting for selectivity biases in the relationship estimated by econometric methods using observations from the merged dataset.

The IT managers' questionnaire elicited (or indirectly will afford objective data on) a number of objective organisational characteristics including the following:

- country location
- specific econ-geographic situation (largest city size in same telephone dialing code area, and average economic and demographic conditions in the province of Europe containing the organisation's dialing code)
- type of organizations (governmental functions, health sector functions)
- size (employees)
- nature of the organisation in terms of government or other non-profit institution
- level of government, and specific type of healthcare institution where applicable
- whether or not there is an IT manager with hardware and applications responsibilities, rather than those functions being handled separately by specialists.

These more-or-less fixed characteristics of each of the organisations in the TDM dataset can be further enriched by the use of the ecological information that may be obtained by tying the regional/city telephone dialing codes for each organisation to the EC's Eurostat statistics and other data for the provinces of Europe. Presently, this may be done for only 5 of the countries covered by the NI 2004 survey, because the necessary dialing codes are not available for Germany, Sweden and Spain.

An almost overwhelming array of information was obtained for each organisation from its IT department respondent (*technical decision managers*, or TDMs, hereinafter) on the use of "networked infrastructure and applications" (and more specifically "Internet-based" applications) to provide citizen and user/client services. An "information technology" profile of these organisations can be described under the headings of Networking Infrastructure, Networked Applications for all the organisations covered by the IT-manager survey. In addition, for the smaller number in the survey administered to business decision managers (BDMs), the organisational technology profiles can be augmented by inclusion of data on the nature and extent of the information system's support of various "business processes".

The data for network infrastructure and networked application provided by IT department personnel responsible for networking technology implementation contains observations on the following variables:

- the nature of the IT department respondents' responsibilities and range of technical initiatives (providing a point estimate of skill/competence)
- the types of network services, and the types of network applications that are being adopted, and the state of the adoption process in regard to each technology
- extent of implementation (percentage of personnel with access), for each application
- the level of CRM (client/customer relations management) sophistication
- network bandwidth, WAN connectivity and availability (uptime percentage)
- the number and identity of the primary vendors of installed networking infrastructure equipment.

Respondents to the IT managers' questionnaire were also asked to supply information on their perceived organisational priorities, and the coherence of the organisation's IT management/procurement policies – as reflected by their more subjective assessments of the effectiveness of organisational implementations of these technologies. These items included:

- the operating outcomes that the IT implementations were asked to achieve within the next 12 months
- which among those goals would be most closely affected by network applications technologies
- their evaluations of the adequacy of systems to handle increasing service demands
- the nature and severity of various barriers to their organisation's successful implementation of IT network infrastructure and networked applications.

In the Figure A-I:1 (see below) we present in schematic form a structure in which this descriptive information can be systematically examined. From this it will be seen that by using the information obtained about technologies that are in the active stage of development it will be quite straightforward to generate estimates of the extent of adoption and internal deployment of the array of specific network services and networked applications. These can be analysed for sub-populations of organisations with similar objective characteristics. Corresponding estimates of current and expected adoption/deployment rates for this array of technologies can be obtained from the observations on the distributions of specific services and applications that currently are "in development", and "planned".

For the sample of business decision-makers interviewed (283 in all, of which 246 form a subset intersecting with organisations from which TDM interview data also was collected), these business managers supplied the following information:

- their estimate of the extent (from 0 to 100%) to which their organisation had automated the following business processes:
  - billing and fee collection
  - case management
  - information and service delivery
  - knowledge management and distribution
  - problem diagnosis integration
  - human resource allocation and management
  - workforce collaboration and training.
- whether, for processes that were automated they accessed tools or data using an Internet or Web-based interface;

- whether or not networked applications were integrated with systems or networks outside the business manager's department, and with which kinds of information sources;
- the nature of the organisational need or objective that led to the automation of "citizen services and/or support activities";
- the timing of process re-engineering undertaken (if at all) in relation to the upgrading of infrastructure and networked applications.

The business manager questionnaires also collected respondents' views on the organisations' key operating goals; the indicators and metrics that were used in tracking impacts of organisational performance under various headings; and subjective assessments of the impact of IT investment implementations dimensions of performance. The information elicited includes:

- whether or not the organisation tracks performance in "client service provision" using specific "metrics" for the following dimensions:
  - **case resolution rates** (average case resolution time, total cases resolved per day/week/month, cases resolved per employee [day/week/month]);
  - **client utilization of the service** (number of citizens using the service, percent of cases resolved by self-service, citizen satisfaction ratings)
  - **financial performance** (annual operating costs, average cost per case resolution, annual fees or revenue collected)
  - **online presence or affordance** (number of visitors to organisation's portal or website, volume of cases/requests filed online, percent of relevant services available online).
- the business manager's priority assignment of a single metric, from the above list, that they would wish to maximize;
- subjective assessments of the impacts or effects on the foregoing dimensions of organisational performance, in terms of percentage changes (whether or not the organisations actually tracks the performance in that dimension);
- assessment of the comparative importance of technology capabilities, as distinguished from technology integration, business process integration, and personnel factors in improving organisational performance ("productivity") in the future;
- other, "non-technological" conditions in the organisation that significantly limit future productivity.

**FIGURE A-I:1 DIMENSIONS OF THE “DINT PROFILES” OF PUBLIC SECTOR ORGANISATIONS**

**NETWORK INFRASTRUCTURE**

**NETWORKED APPLICATIONS**

**PROPERTIES**

**STAGES OF DEVELOPMENT**

External Connectivity  
*Infrastructure*

External Connectivity  
*Applications*

**ALIGNMENT WITH BUSINESS STRATEGY**

**TYPES OF APPLICATIONS**

- Types of Architecture
- Specific Services
- Quality of Service
- Technical Integration

① Active

② In Development

③ Planned

④ Not Contemplated

. Degree of Alignment

(Human Resources, Finance/Accounting, CRM, Content Management, Decision Support, Document Management, Resource Planning)

- Intra-Organisational deployment
- Web Based Services

. Degree of Internal Access to Applications

. Web-based?

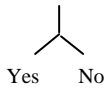
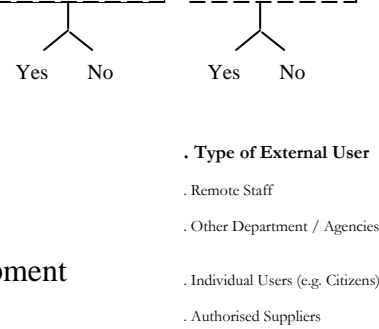
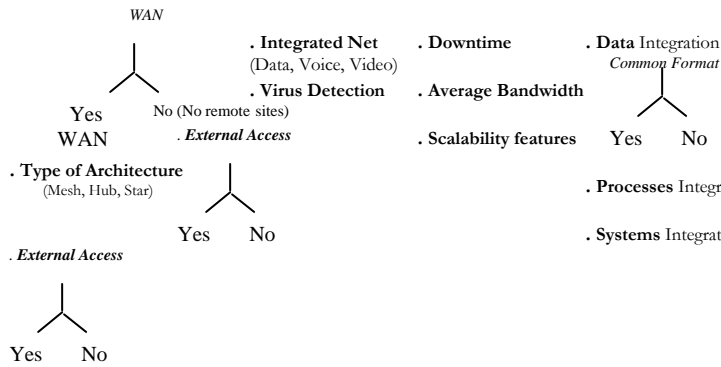


Table I-1  
Size and Composition of NI 2004 Survey Samples and Sub-Samples

(% ) OF EACH CATEGORY IN SAMPLE TOTAL: <sup>a</sup>	Eight-country Samples		Five-country Samples <sup>b</sup>	
	TDM	BDMM	TDM	BDMM
<b>By major organizational characteristics</b>				
<b>REGIONS:<sup>c</sup></b>				
NORTHERN EUROPE	53.1	52.9	38.4	37.9
SOUTHERN EUROPE	40.1	39.0	50.9	50.6
EASTERN EUROPE	6.8	8.1	10.7	11.5
<b>SELECTED EMPLOYEE SIZE CLASSES:</b>				
Largest of 'large' (S > 999)	22.0	19.9	19.2	16.1
All in 'Large' (S ≥ 500)	32.9	32.1	27.0	21.8
All in 'Medium' (99 < S < 500)	37.1	36.2	39.0	40.8
Smaller of 'Medium' (99 < S < 250)	22.7	20.3	23.7	21.3
'Smallest' (25 ≤ S < 100)	30.0	31.7	34.0	37.4
<b>UNIT IS SINGLE SITE ORGANIZATION ("Not WAN")</b>	25.1	25.6	27.4	28.2
<b>By features of organization's network</b>				
<b>ARCHITECTURE OF WAN WITH OTHER SITES</b>				
Star-network	45.7	48.4	46.8	47.1
Mesh-network	10.0	8.1	11.1	9.2
Global backbone	15.3	13.8	11.0	12.6
No response (DK/RF)	3.9	4.1	3.7	2.9
<b>INFRASTRUCTURE BUILT BY SINGLE VENDOR</b>				
No response (DK/RF)	1.5	1.6	1.3	1.1
<b>AVERAGE AVAILABLE BANDWIDTH (bdwd)</b>				
In lowest range: bdwd ≤ 128 kbps	24.3	21.5	28.5	24.1
In top range: (T1+): bdwd ≥ 1.544 kbps	47.0	48.8	41.9	44.8
No response (DK/RF)	10.5	9.8	12.4	10.9
<b>TOTAL COUNT IN SAMPLE</b>	1112	246	709	174

**Notes:** <sup>a</sup> Based on the total sample counts shown in the Table.

<sup>b</sup> The countries for which the organization's city telephone dialing codes are known: United Kingdom, France, Italy, Holland and Poland.

<sup>c</sup> Regions are composed of countries, which are considered broadly "similar" in geography and climate, socio-economic conditions, and cultural heritage.

*Northern:* Germany, United Kingdom, Holland and Sweden; *Southern:* France, Italy and Spain; *Eastern:* Poland.

### ***General methodological issues in the analysis of the NI 2004 survey data***

The motivation for linking the material from the two questionnaires and for making use of the telephone city dialing codes is quite straightforward. The dialing codes provide a link to economic and geographical information from extraneous sources regarding the location and immediate "ecological setting" of these organisations, which may be pertinent in understanding their technology needs and decisions. In addition, the "impact measures" are provided by the interviews with business decision markers, whereas relevant information about the organisations "inputs" resides in the IT department interview responses. Clearly it would be useful to know the specifics of the technological configuration (from the IT department responses) to which the organisations' business decision-makers (implicitly) were referring in offering their impact evaluations, as this would enable us to better understand and interpret the variations among those responses.

No less obviously, it would be advantageous to have more than 246 organisational observations to use for the purposes of statistical analysis. But even this number can be adequate for a pilot, or "proof of concept" study. If the results are sufficiently promising, the possibility exists of enlarging the dataset by drawing a stratified random sample from the (larger number) of IT department interview returns -- taking those organisations that were not surveyed on the first round. (Without further information on the referral and/or response rates to the business decision-maker survey, it is not useful to go into further details about designing future data collection work.)

Rather than simply reporting the unconditional means of the subjective estimates of performance improvements (such as service-quality adjusted measures of output per employee), it will be possible for this pilot study to look at the micro-level statistical association between these impact assessments and the organisation's status in regard to its networking infrastructure, networked applications, and other objective characteristics, including their business process integration and other information management procedures. The resulting data set also will permit introducing "controls" for organisational size, type and level, the primary focal area for IT managers, extent of business process integration, technical competence of IT manager, timing of business process re-engineering (as a measure of good managerial practice), and still others.

### ***Specific issues of statistical methodology***

A range of alternative statistical (econometric) methods could be used to permit meaningful analysis even of a dataset containing only a couple of hundred micro-level observations. For example, principle components analysis of the organizational characteristics could reduce the number non-technological variable, replacing them by, say, the first three or four principle components. This approach could also be used for date reduction in the case of the technological characteristics. The relationship between subjective estimates of (quality adjusted) labor productivity improvements and organisational (input) characteristics could then be explored by regression methods, under the supposition that the latter characteristics were pre-determined variables whereas the performance improvement measure was the dependent variable.

#### ***Endogenous variables:***

How the results of such regression models are to be interpreted depends, obviously, on the nature of the variable entering the regression equation and the validity of the assumptions about distribution and independence of the errors associated with those

variables. Without entering into technical details here, it should be noted that because we have an assessed change in productivity, without any corresponding information on the magnitudes of the associated *augmentation* of technological and organisational/managerial input intensity (per employee), the statistical relationship yielded by the foregoing approach would not properly be interpretable as a production function – even under the statistical assumptions described above. Further, it may well be the case that the assumptions about the independence (or “exogenous” or predetermined nature of the input variables) is not valid. The networked technology investments and implementation practices of the organisations could reflect preconceived, actual and perceived past “effects” on the organisation’s productivity; or they could be jointly determined under the influence of some latent feature(s) of the organisation, such as the quality of the technical and organisational managers.

Nevertheless, without going all the way to estimating a dynamic “production function” that would permit statements about the causal influence of networking infrastructure and networked applications upon an organisation’s productivity (and other dimensions of performance), a descriptive analysis of the integrated dataset could be informative in revealing statistically significant patterns of association between the two sets of variables. This more modest goal, empirically ascertaining detailed morphologies of “best practice” in the utilisation of networked information technology for this important class of organisations is certainly within reach on the basis of the type of data that the Momentum study has provided.

*Unobserved heterogeneity:*

The impacts that are statistically attributable to (i.e., associated with) particular configurations of observed “objective” features of the organisation may in this way be distinguished from other sources of variation in reported performance, which, in the simplest form of analysis, would include both subjective elements and reporting biases in “perceived impacts,” and differences among organisations’ objective attributes that were not covered by the Momentum survey (“unobserved heterogeneity”, in technical parlance). The latter might include, for example, the length of time that the organisation had been working with the technologies in question; the relative priorities held by various organisation goals in budget allocation decisions by top level management; incentive structures within the organisation that may affect staff performance and morale.

The “effectiveness” of an organisation in providing client services is affected, however, by conditions external to the organisation. The latter include the performance of complementary and substitute service providers. To illustrate this point, consider that the delivery of emergency care in hospitals is likely to be affected by the condition in which trauma victims arrive for treatment via ambulance service, and hence by the integration of the latter’s information system with that of the hospitals in the service region. (The latter would affect the timely provision of paramedical data and diagnoses on incoming patients, and data on the emergency room capacity/congestion status of the hospitals that could be use for more efficient routing of the ambulance service.) The focus on internal IT and business process factors in the Momentum Research Group’s *Net Impact 2004* study -- a focus found also in numerous studies of IT impacts on business productivity -- does not make it possible to pursue the details of such external interaction effects empirically. Yet, statistical controls for the type of organisation and the nature of its services may permit identification of circumstances where such effects are not likely to be very powerful, and so remove a potential source of imprecision and bias in the empirical regularities that can be observed solely on the basis of internal data.

There remains another broad class of “external” conditions that will remain less than



fully "controlled for" by the proposed design of the statistical analysis: inter-organisational differences in the characteristics of the client population. Thus, differences in the degree of access to, and familiarity with Internet transactions on the part of the sub-populations that the different organisations are serving, is a potential source of performance variation even where the latter measures are defined purely from the perspective of the service organisation. To the extent that such differences were systematically associated with the nature of the services being provided, or with the national (or geographical) location of the clientele, however, their effects could be controlled by the use of extraneous ecological data as well as fixed organisational characteristics available in the merged sample dataset.

*Management perceptions vs. objective measurements of productivity impact:*

Of course, it would be more desirable not to have to rely upon the reported perceptions of organisational decision-makers for our measures of productivity and unit cost impact, and instead, work with objective statistical indicators of actual changes in service-provision per unit of labor (and other resource inputs) in these organisations. It does not appear beyond the bounds of feasibility to contemplate future surveys being conducted that asked technical and organisational managers for concrete statistics on each of the "impact" dimensions that were being tracked in their own organisations. Indeed, a repeat of the survey for a panel of organisations at a 2-year interval would open the way to actually identifying and gauging causal relationships between input changes and output changes. Yet, as desirable as taking that step towards actual productivity analysis would be, it would not dispose of all the problems that beset the study of determinants of organisational performance in client service activities.

The following is the nub of the deeper problems that remain: "performance" may be defined and measured either from the perspective of the "server" or from that of the "served," and the two assessments may or may not concur. Indeed, they may be inversely associated. For example, "resolution" of cases/requests can be defined in terms of executing a transaction in which information is supplied in response to an enquiry. The requestor may be given incorrect information, or correct information that does not address their need because the latter was not properly elicited in a brief or pre-programmed request process. This may generate a second request, which also can be "resolved". Measures of "requests resolved" per employee may show improvement, and adjustments for speed of resolution could be viewed as revealing even greater "quality-adjusted" gains; whereas the number of repeat requests per client case, not to mention client time and frustration, would show just the opposite performance trend when evaluated in terms of clients utility. Clients who discontinue attempts to obtain a service have not had their "cases" resolved in terms of their satisfaction, even if the organisation is able to "close" the case file that bears their reference number.

Thus, it will be important to bear in mind that where the public services involved are unpriced transactions, and where some of the transactions are mandatory for the clientele, an index of improvements in task performance rates per unit of input tells us something about changes in organisational unit costs. But this notion of "productivity" does not automatically admit of the conventional economic welfare being assigned to "output" as a proxy for consumer satisfactions (quantity of goods and services delivered, evaluated at relative prices--which in perfect competitive equilibrium are equal to relative marginal utilities of consumption of the good involved). One must therefore be alert to the possibilities that changes in the mode of task performance that register as unit cost improvements may have altered the attributes of the service in ways that do not yield correlated reductions in the social costs of client satisfaction. Without independent evaluations of the output from the clients, this limitation in the results obtained remains unavoidable.

*Sample representativeness and corrections for selection biases:*

As has been noted, the possibility of adjustments for the sample selection biases in the matched BDM and TDM responses is a second important advantage of the proposed data linkage. The criteria applied by Momentum Research, and the market research company Synovate,<sup>1</sup> in selecting the organisations represented in the business decision-maker sample are briefly described in Annex 1 of the NI 2004 Report as the resultant of a two-stage process: from some 30,000 possible organizations a 4 percent sample of (1200) technical IT managers was targeted for interview, distributed uniformly across 7 of the 8 countries (with only half as large a target sample specified for Poland). The completion rates among the targeted organisations (i.e., those contacted and agreeing to participate) approached 93 percent in this first stage. But, the representativeness of the first stage targeted group – produced by the application of the technical selection criteria imposed for this study, and the self-selection process reflected in the willingness of organisations to participate – cannot be determined from the information provided in the NI 2004 Report. Next, from among the targeted first stage organisations, 40 organisational decision-maker interviews were targeted in each country excepting Poland, split evenly between government and healthcare organisations; only 20 interviews, exclusively with government organisations, were conducted in the case of Poland. The second stage target represented a 25 percent sample, and within that group the completion rates were again high, at a bit over 94 percent. This implies that an integrated dataset would contain 23.6 percent of the first stage target organizations, and 25.4 percent of the organisations that provided completed responses in the first stage.

Although it is unlikely that anything can be done in the near term to ascertain how representative of the population of 32,000 organisations were the 1200 that formed the first stage interview target group, the selectivity biases among the second stage responses can be conveniently studied by comparing the distribution of organisational characteristics of the 829 stage one questionnaire respondents that are not in the integrated dataset with those of the 283 organisations that it contains. By taking account of the differences in IT systems, size, location, service type, and other objective characteristics of the two sub-populations, it will be possible (using well-known econometric procedures, e.g., the Heckman correction factors) to adjust for the effects of selectivity bias in the relationship observed between those features and the subjectively assessed productivity impacts. Implicitly, this correction could deal with a two-fold effect: first, it is conceivable that the distribution of the objective organisational characteristics of the integrated sample is a non-representative draw from the underlying distribution, and one that is conducive to particularly strong (or weak) perceptions of productivity gains; second, it is conceivable that the distributions of perception and reporting errors on the part of business organisation managers are correlated with the objective IT system status of the organisations, and therefore would impart a bias in the assessed impacts that reflected the organisation-level selectivity bias that is present in the integrated dataset.

Even if we cannot with the presently available data aim to estimate a causal model that would justify imputing productivity effects to certain forms of technology investments (in networking infrastructure and applications, organisational business process re-engineering, and staff competence levels), the foregoing adjustments for sample selectivity

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<sup>1</sup> Synovate ([www.synovate.com/whatwedo/other/omnibus](http://www.synovate.com/whatwedo/other/omnibus)) is the market research arm of communications specialist Aegis. Based in West Malling, Kent, UK, Synovate's Sample Surveys Research Group offers a wide range of global market research services, including surveys of central and local governments and public utilities (contact: [helen.turner@synovate.com](mailto:helen.turner@synovate.com)).

would be quite important in forming a more intelligible view of the patterns of association between reported productivity gains and objective organisational characteristics on the basis of the integrated dataset.

Carrying out this exercise would also serve to indicate the magnitude of the sample selection biases present in the data collection procedure, and consequently be a guide to the design of future surveys. This seems quite important a step to take, in view of the scope that has been shown to exist – by the Momentum reports -- for the systematic collection of highly informative systematic data on the technology acquisition and implementation status of public sector service organisations and their effectiveness.

### **A-I.2 Questionnaire Design and Field Implementation Procedures in the NI 2004 Survey: Problems and Recommendations for Future Work**

The following summarizes various problematic aspects of the datasets created by the NI 2004 Survey, upon which the foregoing section has remarked. All the issues noted originate either in the questionnaire design, or the survey sampling procedures, or the data retention rules followed when the surveys were fielded. The nature of the key problem discussed in each instance is marked in boldface in the following review. In each case we offer brief recommendations for desirable changes, some of which may be pertinent to improving the quality of the data gathered in the next stage of the Net Impact data collection program -- in countries such as Portugal, Egypt and Turkey. Other recommendations contemplate the possibility of future targeted surveys of western European public sector organisations.

1. It would be more desirable not to have to rely upon the reported perceptions of organisational decision-makers for our measures of productivity and unit cost impact, and instead, **work with objective statistical indicators** of actual changes in service-provision per unit of labor (and other resource inputs) in these organisations.

*Recommendation:* Assess the feasibility of conducting future surveys being conducted that asked technical and organisational managers for concrete statistics on each of the "impact" dimensions that were being tracked by their own organisations. Indeed, **a repeat of the survey for a panel of organisations at a 2-year interval** would open the way to actually identifying and gauging causal relationships between input changes and output changes.

2. It is of foremost importance to add at least some **indicators actually measuring "performance" in public sector provision of services**. (This additional question could easily be introduced following from Question 9a in the BDM survey protocol, where the respondent has answered that the organisation they actually track its performance in regard to one of the 12 metrics in the list.

*Recommendation:* Respondents should be asked the date when tracking of the metric commenced, and this information should be recorded. Indicators of performance of that metric during the past month, and (where relevant) during the same month of the previous year, should be asked for. It would be particularly useful to do this where any of the following "productivity metrics" were tracked by the organisation: average cases per employee, average time to resolution of citizen requests/need, average cost per case resolved. The same procedure should be followed also when the respondent reports that "Citizen Satisfaction" measures are being tracked. In that case it is important to preface the question by asking: "What

metric do you follow in tracking 'citizen satisfaction' with the service(s) your organisation provides."

3. For organisations already monitoring network services deployment and delivery, equivalent **measures of "actual" and effective indicators of deployment** (such as what fraction of computers in the facility are currently networked, or can access a given network application) should be sought in interviews with technical decision managers.

*Recommendation:* At least some objective measures of deployment should be collected both for Network services and for Networked Application, in addition to asking respondents to estimate the extent of such deployment.

4. When posing questions intended to elicit quantitative information about continuous measures, such as the extent of deployment measures as percentages of personnel, **it is better in some instances not to offer pre-determined ranges as candidate answers** (e.g., quintals of the percentage distribution from 0 to 100). The continuous distributions of responses can be subjected to analysis of the extent of "heaping" on salient numbers (e.g., deciles and quartile intervals), thereby affording an assessment of the likely accuracy of estimates provided by respondents in organisations having specified objective characteristics, and the corresponding weighting of the data in subsequent statistical work. Categorical responses also pose special statistical problems in some contexts.

*Recommendation:* In at least some instances where it would be possible for the respondent to actually obtain a numerical estimate of some important objective condition in the organisation, such as the proportion of desktop computers that are able to access a specified network service, point answers (a number, or percentage) rather than ranges should be requested.

5. **Information about the geographical location of respondents** is potentially valuable for purposes of subsequent analysis and should be retained in every instance by the interviewers. Knowledge of the regional dialing codes can be linked to other "contextual" variables for the region in question by mapping the dialing code area to statistical and economic datasets for the geographic provinces in question. This will enable both the "technology profiles" of individual public organisations and their performance to be analysed holding constant certain "ecological variables" (e.g. regional infrastructure, networking profile of region, demographic composition of client population, etc.)

*Recommendation:* The dialing code(s) -- at least for the city/region -- should be appended to the individual survey returns in the final dataset. The full telephone numbers should be retained for potential use in targeted call-back seeking updating of information at a later date, thereby permitting construction of panel data by "capture-re-capture" methods applied to a sub-sample of originally surveyed population.

6. **A unique code should be used** for identification of the same public organisation, common to the survey of technology managers and business managers.

This will facilitate linkage of the technical decision manager survey return with the business manager survey return for the organisation in question, which is essential if data from the former are to be compared with and used to analyse responses from the latter of the pair of surveys.

7. **The procedures and statistical sampling rules used to arrive at the targeted number of responses to the TDM survey are not described.** It is unlikely that anything can be done to ascertain how representative of a larger population of 30,000 organisations was the sub-sample of 1200 that formed the first stage interview target group, and although some 2000 organisations appear to have been contacted in that process, no information appears to have been retained about the unproductive contacts. Absence of that data makes it impossible to discern the respects in which the target group may or may not be representative of the population of “eligible” organisations that were approached.

*Recommendation:* (a) In order to permit assessment and correction of selectivity bias in the TDM survey, some information about the reasons for why no return was obtained should be noted (i.e., ineligible due to size <25, or due to not being “connected,” or non-cooperative contact).

8. It would appear that in fielding the NI 2004 Survey the intention was to achieve “proportionality” in the number of responses to the TDM and BDM survey instruments across the array of countries, and that this was more-or-less achieved – with the exception of the short-fall in the BDM returns for Poland. **Whether the BDM survey was fielded as a random or a systematic sampling of the TDM survey organisations is not stated, and the procedure following in obtaining the targeted number of returns in the second survey is still less clear.** Nevertheless, the existence and nature of selectivity biases in the BDM survey responses can be studied by comparing the distribution of organisational characteristics of the 829 stage one questionnaire respondents that are not in the integrated dataset with those of the 283 organisations that it contains. But, it is of greater interest to ascertain information about the representativeness of the somewhat smaller number of organisations in the “matched” 246 organisations for which TDM and BDM questionnaires have been paired. It is evident from the discrepancy between the number of BDM survey responses (283) and the number of matched TDM-BDM questionnaires (246) that in the case of some organisations the attempt to obtain the second set of responses did not succeed. But, how many such refusals actually occurred, and which organisations among the TDM survey population were involved, has not been disclosed.

*Recommendation:* Data and information should be kept in the final dataset for the organisations to whom an interview was requested for “business managers” sampling but from which no reply was effectively collected. A new field code should be used in the final dataset for identification of these organisations among those in the final TDM survey dataset.

## Addendum to Part II

### A-II.1 Technical Notes on Diffusion and Aggregate Labor Productivity Growth

#### 1. A Simple Model of the Effect of Technology Diffusion on Sectoral Productivity Growth<sup>2</sup>

We envisage a discrete innovation that results in lower labor input requirements per unit of output, compared with a pre-existing technology. Hence, the level of average labor productivity in the industry, sector or economy into which it is introduced will be determined as the weighted average of the labor productivity levels characteristic of the new and old technologies, the weights being given by the extent of the innovation's diffusion. By "direct effect" is meant the impact upon the aggregate level of productivity of a redistribution of production from the old to the new-style process, the latter being more efficient in its use of inputs. By "indirect effects" are meant the whole range of (positive feedback) consequences that more widespread use of the new technology has upon its relative level of productivity — vis-à-vis the old technology — in all applications.<sup>3</sup>

For simplicity, the main relationships posited here are of a "reduced form" character. That is to say, they do not explicitly exhibit the microeconomic conditions governing decisions by producers to adopt the new technology, nor the decisions by suppliers of the new process-equipment to make available enhancements, nor the ways in which users acquire greater proficiency in application of the new technology. Consequently, although consistent with a fully specified model of that kind, the analysis relating the rate of diffusion (and the extent of diffusion at a specific point in time) to the aggregate productivity growth rate of the sector will be limited: it cannot exhibit the complex interdependence that would exist between the pace of the new technology's diffusion and the rate of (endogenous) improvements stemming from experience with the new technology. On the other hand, that does not necessarily preclude conveying an empirically plausible picture. Were there other sources of change affecting user-costs of the new technology, in addition to experience-based improvements in input efficiency, it is quite plausible that the specifications employed here present a consistent picture of the aggregate productivity impacts of the diffusion process *per se*.

#### ***The model: definitions and assumptions***

The following notation refers to an industry, sector or economy producing a homogeneous output,  $V$ :

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<sup>2</sup> The material in section 1 of these Notes has been largely drawn from P. A. David, "Zvi Griliches on Diffusion, Lags and Productivity...Connecting the Dots," Forthcoming in *Annales de Économie et des Statistiques* [Selected Papers from the Conference in Memory of Zvi Griliches, held in Paris, September 2003], eds. J. Mairesse and M. Trajtenberg, Winter 2006. Revision of paper available at: <http://siepr.stanford.edu/papers/pdf/02-45.html>. A previous version of the basic portion of the model presented here was published (as an Appendix) in P. A. David, "Computer and Dynamo: The Modern Productivity Paradox in a Not-Too-Distant Mirror," in *Technology and Productivity: The Challenge for Economic Policy*, Organization for Economic Co-operation and Development, Paris, pp. 315-48.

<sup>3</sup> The context of application here refers to different production facilities, all of which are supposed to involve essentially the same production operations. This abstraction from reality is worth noting, especially when one considers the diffusion of so-called "general purpose technologies" whose adaptation to the requirements of different industrial applications may entail significant collateral investment in technological improvements and organizational changes, as has been noted widely in regard to ICT innovations.

- $\pi_j(t)$ : is output per unit of labor input using the  $j$ -th technique at time  $t$ ,  
 where  $j = 0$  represents the "old" technique and  $j = N$ , the "new" technique;  
 $\pi_N(t) \geq \pi_0(t)$  for all  $t$ .
- $D(t)$ : is the proportion of aggregate output produced using technique  $N$ , at time  $t$ ;
- $\pi(t)$ : is aggregate labor productivity at time  $t$ ;

Aggregate labor productivity can be found as the inverse of the weighted harmonic average of the average labor productivities of adopters and non-adopters, the weights being the respective shares of the two groups of producers in the sector's aggregate output. Thus, with a little manipulation,  $\pi(t)$  may be expressed as:

$$\pi(t) \equiv \pi_0(t) [1 - D(t) \{1 - (\pi_0(t) / \pi_N(t))\}]^{-1} . \quad (1)$$

*Assumption 1:*  $\pi_0(t) = \pi_0$  for all  $t$ .

This holds that the old technology undergoes no improvement or deterioration in its (fixed) unit labor input requirements. For simplicity, we shall suppose the old technique uses only labor, so that  $\pi_0$  cannot be affected by factor substitution.

$$\text{Assumption 2:} \quad \pi_N(t) = \pi_N \{D(t)\}, \frac{\partial \pi_N}{\partial D} > 0, \frac{\partial^2 \pi_N}{\partial D^2} < 0.$$

This posits an "improvement function" for  $\pi_N$ , s.t. labor productivity with the new technique will increase as the process becomes more widely diffused, although such incremental enhancements predicated upon diffusion experience will be subject to diminishing marginal returns.

### ***Determinants of the labor productivity growth rate***

We use the convenient (if slightly unconventional) notation for proportionate rates of change by a dot placed above the variable in question, e.g.,

$$\dot{\pi}(t) \equiv \partial \ln \pi(t) / \partial t \text{ is the proportional growth rate of } \pi(t).$$

To find the general expression for the growth rate of labor productivity,  $\dot{\pi}$ , in terms of  $D(t)$  we first rewrite (1) as follows

$$\pi(t) = \left( \frac{\pi_0}{1 - [\beta(t)]D(t)} \right), \quad (2)$$

$$\text{thereby implicitly defining } \beta(t) \equiv \left[ 1 - \frac{\pi_0}{\pi_N(t)} \right].$$

Differentiating (2) with respect to  $t$  and multiplying through by  $[\pi(t)]^{-1}$ , we obtain the basic expression for the labor productivity growth rate:

$$\dot{\pi}(t) = \left( \frac{d\pi}{dt} \right) \frac{1}{\pi} = \left[ \frac{\beta(t)}{1 - [\beta(t)]D(t)} \right] \frac{dD(t)}{dt} + \left[ \frac{[1 - \beta(t)]\varepsilon(t)}{1 - [\beta(t)]D(t)} \right] \frac{dD(t)}{dt}, \quad (3)$$

where  $\varepsilon$  denotes the elasticity of the average labor productivity within the adopting sub-sector with respect to its share in total production:  $\varepsilon(t) \equiv \frac{\partial \pi_N(t)}{\partial D(t)} \cdot \frac{D(t)}{\pi_N(t)}$ .

The first term on the RHS of (3) gives us the *direct effect* of diffusion, which is the total effect in the simplest case where neither the new nor the old technologies undergo any change in their respective unit labor input requirements, i.e. where  $\varepsilon(t) = 0$ , and  $\pi_N(t) = \pi_N(0)$  for all  $t$ .

The second item on the RHS, obviously, gives the *indirect effect* of a change in the extent of diffusion upon  $\dot{\pi}$  — via the induced incremental improvement of the new technique's productivity in all uses. These induced improvements in the absolute (and, by assumption) relative level of labor productivity with the new technique may be interpreted as deriving from accumulate experience in introducing the new production methods — which is reflected in the measure of diffusion, or, the positive network externalities that users enjoy as a consequence of the widening diffusion of the technology within the sector as a whole. The two interpretations are not mutually exclusive, and both appear germane to the present context in which this general model is to be applied.

### ***Implications: timing of the peak in the rate of productivity growth during diffusion***

The answer to this question is a little counter-intuitive, because productivity does not grow most rapidly when the extent of diffusion is rising at its fastest pace. One may see this most easily by considering the simplest case, where there are no indirect learning effects that alter the relative productivity of the new technology vis-à-vis the one that it is displacing.

But, the proposition also holds more generally. By imposing the restrictions  $\varepsilon(t) = 0$  and  $\pi_N(t) = \pi_N(0)$ , so that  $\beta(t) = \beta > 0$  for all  $t$ , we obtain from (3) the expression for the labor productivity growth rate where only the direct effect of diffusion is operating:

$$\dot{\pi}_1(t) = \left( \frac{\beta}{1 - \beta D(t)} \right) \frac{dD(t)}{dt}, \quad \beta > 0, \quad (4)$$

where the subscript 1 denotes the simplifying restrictions imposed on equation (1).

Evidently,  $\dot{\pi}_1$  is not simply proportional to the change in the extent of diffusion ( $dD$ ), and therefore it will not reach a maximum when  $dD/dt$  reaches its maximum. This is readily shown by differentiating  $\dot{\pi}_1(t)$  with respect to time, whence we obtain



$$\frac{d\dot{\pi}_1(t)}{dt} = \left( \frac{\beta}{1-\beta D(t)} \right) \left( \frac{d^2 D}{dt^2} \right) + \left( \dot{\pi}_1 \right)^2, \quad (5)$$

from which it follows that

$$\text{at } \max \frac{dD}{dt}, \frac{d^2 D}{dt^2} \rightarrow 0, \text{ and } \frac{d\dot{\pi}_1(t)}{dt} \rightarrow \left( \dot{\pi}_1 \right)^2 > 0.$$

For the typical case,  $[\max(dD)]$  occurs in the interval  $(0,1)$ , which implies that  $\left[ \dot{\pi}_1 | \max(dD) \right]$  cannot be at a maximum. Since the term in brackets ( ) on the RHS of equation (4) is increasing monotonically in  $D(t)$ , the  $\max \left\{ \dot{\pi}_1(t) \right\}$  will occur at a time after  $\max(dD)$  has been reached.

It is now straightforward to demonstrate that this result is more general: it holds strictly when there is no change in the elasticity parameter that describes the dependence of the indirect "learning effects" upon  $D(t)$ , i.e., for all  $\epsilon(t) = \epsilon(o)$ . The way to see this is to define a new parameter,

$$k = (1-\epsilon) + \epsilon / \beta,$$

and notice that the basic differential equation (1) for the sum of direct and indirect effects then may be written in the alternative form:

$$\dot{\pi}(t) = k \left( \frac{\beta}{1-\beta D(t)} \right) \frac{dD(t)}{dt}, \quad \beta > 0, k > 0. \quad (1a)$$

From this it follows immediately that the value of  $D(t)$  at which the whole expression for the labor productivity growth rate reaches its maximum will coincide with that obtained for the special case when only direct effects are present:  $\max \dot{\pi} = \max \dot{\pi}_1$ .

A further, empirical implication should be remarked upon. When the time-path of the extent of diffusion (measured as the proportion of total output capacity provided by the new technology) takes the classic S-shaped form described by the logistic distribution, the annual change in the extent of diffusion ( $dD$ ) will reach a maximum (the inflection point of the curve) where  $D = 0.5$ . In other words, under the stated conditions, the peak growth rate of labor productivity would necessarily occur after the extent of diffusion had passed the "half-way" mark. Moreover, further postponement of the productivity growth peak would result where the elasticity of the innovation's indirect effects is not constant, but instead increases as the innovation becomes the dominant technology within the sector. Such "delayed positive feedback" effects on the differential between productivity levels characterizing the new and old technologies are quite likely to be important where there are significant network externalities, and labor force training externalities that accompany more widespread adoption of the innovation.

## 2. Notes on empirical implementation of the model

An illustrative calculation of the growth rate of aggregate labor productivity in the western European public sector may therefore be made by using the macro-level diffusion estimates denoted as  $D(1)$ ,  $D(2)$  and  $D(3)$  in conjunction with a weighted average estimate of the proportionate increase in average cases resolved per employee, implied by the regression estimates reported in Part III, Table III-1:Panel 2. The results are those reported in the text at the end of Part II, sect. 1. It will be seen from the following discussion here that in order to bring these two pieces of information together within the framework of the model set out in section 1 of this Addendum, quite a number of additional assumptions and supplementary calculations of a very approximate kind are required. The description of the procedure that follows should stand as testimony to the largely heuristic purpose of this exercise, and as a caution against regarding the results as having achieved the degree of precision and reliability that could be obtained by applying the theoretical framework for these calculations in a more elaborate and detailed manner.

### *2a. Estimating the time-path of the overall measure for the extent of diffusion*

We start by implementing the simple model described by equation (1a) for the special case where  $k = 1$ , that is to say, where  $\epsilon = 0$  and are no indirect effects associated with further technological improvements induced by diffusion based experience. It is then sufficient to know the time-path of the diffusion measure  $D(t)$  and the ratio between average labor productivities with the new and the old technologies, from which the parameter  $\beta$  is derived – following the definition in equation (2). To know the time-path of  $D(t)$  as the latter is defined in the model of section 1 (above), however, is not quite so straightforward when starting from diffusion measures of the kind that appear in Part II, Table II-1. The latter rest on the proportions of *organisations* in the surveyed countries that had adopted, and were planning to adopt the indicated class of novel technology; whereas the measure  $D(t)$  as defined by equation (1), above, relates to the proportion of *output* that is produced using the new technology. Since the organisations in the public sector vary in employment size, the share of “output” produced with the new technology will be greater than the share in the population of organisations even if the proportions of organisations adopting the technology were the same, regardless of their size.

But in addition, it is observed that the extent of inter-organisation diffusion ( $D(1)$ ) is greater for the large organisations, i.e., those having more than 499 employees. Addendum II Figures A-II:1-2 (below) exhibit the average proportions of organisations that had adopted each of the individual network service and networked applications technologies, for each of the three major size classes. The tables in Part II, showing the distribution of organisations according to the technology “profiles” to which they are assigned are generally consistent with the view that the larger organisations in each region tend to have led in acquiring more advanced technologies. Although it is possible to calculate approximate employee size weights for each organisation, and to use those to obtain pseudo-estimates of the share of output produced with each technology – on the assumption that per worker productivity depended only on whether or not the technology had been adopted, and therefore was uniform across units regardless of their employment size – this laborious set of computations has not been performed. It is more in keeping with the present, illustrative exercise to obtain a rough correction factor that will translate the measure of diffusion based on the proportion of organisations into one indicating the proportion of aggregate output. In other words, some simplifying assumption will suffice to

provide approximations of the level and trend in the ratio  $[D(t)]/[D(t)]$ , where the denominator corresponds to a diffusion measure based on the share of organisations that use the new technologies.

To obtain that correction factor we make two basic simplifications: (1) we work with only two employee size classes, large and small, where the former corresponds to organisations with 500 or more employees, and we note from Tables II:2 and 3 that the large-organisation's share of the TDM sample population is  $\omega_L=0.33$ ; (2) we posit that the average labor productivity differential associated with use of the innovation is the same --  $[\pi_N(t)/\pi_0]$ -- regardless of the organisation's size. The magnitude of the correction factor for a given date can then be obtained by fixing two additional parameters:

$\mu = D_S/D_L$ , is the ratio between the extent of diffusion in the small organisation group and the same measure for the large organisation group;

$\sigma = e_S / e_L$ , is the ratio between the average number of employees per organisation in the small and large size groups, respectively;

Given either  $D$  or  $D_L$ , the other can be obtained from the identity:

$$D = D_L[(1 - \mu)\omega_L + \mu].$$

That completes the list quantities needed to compute a corresponding point estimate of  $[D(t)]/[D(t)]$ . The expression for the latter is algebraically straightforward--albeit cumbersome and tedious to derive -- and need not be reproduced here. Suffice it to say that it makes use of the definitions of  $D(t)$  from equation (2), as well as that for  $D$ , given above; and it represents the output of the groups of organisations of different sizes as weighted sums of the product of numbers of employees and average employee productivity for the portions of adopters and non-adopters within each size group. An initial level for the correction factor of  $[D(t)]/[D(t)] = 1.23$  is obtained with the following parameter values that can be approximated using the end-of-year 2003 survey data:  $\omega_L=0.33$ ,  $\mu = 0.7$ ,  $\sigma = (200/800) = 0.25$ , and  $D_L = 0.7$ . To allow for changes in this ratio as a result of the projected rise in the extent of diffusion (to be considered shortly) and the tendency toward convergence in the extent of diffusion among the size groups, which is evident from the contrast between the  $D(3)$  and  $D(1)$  measures in Figures A-II:1 and 2, we make a second point estimate using the values  $\mu = 0.75$  and  $D_L = 0.8$ , holding all the other parameters unchanged. Even though the resulting rising correction factor must approach the implied higher value at a slow average annual rate (because it cannot drive  $D(t)$  beyond its upper limit of 1), it rises from 1.23 to 1.54 within the next three years.

The next step is to transform the current and projected estimates of the proportion of organisation using e-network technologies in the 8-country region (as shown in Part II, Table II-1) into estimates of the time path of an aggregate diffusion measure based on the "proportion of organisations adopting" this class of innovation. To do this, we date the  $D(1)$  measures relating to the "current" extent of aggregate diffusion measures as referring to the end of 2003; we then assume that the technical decision managers' statements about technology acquisition plans refer to a notional "five-year-planning period", so that the  $D(3)$  in Table 11-1, which give a near-term average projected extent of diffusion among currently connected organisations in the 8 countries can be read as referring to the end of 2008. There are clearly two different diffusion trajectories indicated by the 8-country aggregate measures of diffusion, one referring to a basic level of network services and applications relating to the first row entries under each of those headings, which, roughly speaking moves from  $D(1) = .73$  to  $D(3) = .89$ , a change averaging 0.032 percentage points per

year; and the second referring to a more advanced technology profile, represented by the second and third rows under each heading, which moves from roughly  $D(1) = .325$  to  $D = .705$ , and a change averaging .076 percentage points per year. Rather than assuming exponential growth in the extent of diffusion, we interpolated a “three-year plan” projection on the basis of the  $D(2)$  measure.

Then, working with the implied trends for network service technologies and networked applications, we calculated the year-to-year changes in the extent of diffusion for each, equally weighted the annual rates of change, and taking the average found for the currently active diffusion measure at the survey date ( $D = 0.325$ ), we constructed the time path of  $D(t)$  for each year up to 2008. The year-to-year absolute increases in  $D(t)$  reach a maximum in 2006 and then fall back to the same level during the two years 2007-08 that characterized the years 2004-05. But what matters for our calculation of the rate of growth of aggregate labor productivity are the estimates for the time path of the share of output produced by adopting organisations. The upward trend is  $D(t)$  that is implied by our correction factor is quite vigorous: this measure of the extent of diffusion stands at 0.40 at the end of 2003 but already reaches the 0.89 level at the end of 2006. Its rise slows dramatically thereafter, as it approaches the upper boundary at 1.0.

***2b. Obtaining a comprehensive estimate for the average labor productivity differential:***

It remains to piece together an overall estimate of the average productivity differential on the basis of the findings (discussed in Part III) concerning the impact of adopting and deploying these networked information technologies on the best of the available productivity metrics: the number of cases resolved per employee. The goal is a comprehensive average value for the productivity differential  $[\pi_N(t)/\pi_0]$  associated with new technology adoption, but we start by focusing on the impacts of acquiring technologies in the meta-clusters above TMC1. The average productivity gain among the connected organisations studied in Part III is found to be about 36 percentage points.

This figure reflects several assumptions that are required to weight the regression estimates presented in Table III-1 (Panel 2) for the different categories of organisations. First, as the numbers of health and government organisation are roughly matched, we give equal weights to the proportional productivity gain estimated for each of those types. For organisations other than those in meta-cluster TDMC3, the average productivity impact is 35 percentage points. Second, in allowing for the performance impacts in organisations that attain the TDMC3 profile, with the assumption that half of those will follow the effective “best practice” of integrating business processes with network services and applications, the average come out to be a 39 percentage point increase. But, we note that at the mid-point of the 5-year interval the number of organisations that are not in TDMC3 and in all the other meta-clusters other than TDMC1 is 686, whereas 162 organisations were assigned to TDMC3; hence the share of the latter in the combined total is 0.2, and using that as the weight for the 39 percentage point productivity differential, and applying the .8 weight to the 35 percentage point average for the others, we arrive at the 36 percentage point overall productivity differential.

Whereas in the case of “connected” organisation we can put the average productivity differential at  $[\pi_N(t)/\pi_0]=1.36$ , the Momentum Group’s sample drew 1112 eligible organisations from its target list of 2000, giving a estimate of the “unconnected remnant” as being .444 (= 1-0.556) of the total population. Let us assume that of those only 0.4 will join the ranks of the “connected” and experience the same average differential as those not in

TDMC3, i.e., a 35 percentage point productivity gain. On that premise, the average gain among the .44 of the population that was not connected in 2003 would be 14 percentage points. Calculating the corresponding magnitudes of  $(1/\beta)$  we have 3.77, and 8.25 for the connected and unconnected sub-groups, which give a share-weighted average of  $(1/\beta) = 5.76$ , corresponding to an overall differential of 1.21.

But now we must make a corresponding adjustment of the diffusion measures to take account of the presence of the small and still un-networked organisations ("the unconnected remnant"), and the entry of some of these into the ranks of the "connected." To begin with, the 0.44 share of initially unconnected organisations contributed something to the aggregate "output" of the sector, so that the initial proportion of production coming from the e-technology adopters (defined here as "connected") is smaller than the 0.4 figure previously obtained by considering the pseudo-output-weighted diffusion measure for the connected organisations at the end of 2003. If one supposes that the total output of the eligible (connected) organisations was 0.9, then the aggregate share of the entire sector's output produced with e-network technology would be about 0.36 ( $0.9 \times 0.4$ ). This seems quite plausible –not because it turns out to be in the near neighborhood of the  $D(1)$  measure for the connected group based on the number of adopting organisations, but because of the other implications of the 0.9 output share assigned to the initially connected sub-sector. Since the initially unconnected remnant would have been responsible for 0.1 of total output, and since they represented 0.44 of the number of organisations, the implied relative average output per organisation was 0.23 of the average of all organisations. By contrast, the implied relative output of connected organisations was 1.61 ( $= .90/.56$ ), or 7 times that of the typical small and/or non-adopting organisation. (Given that some number of the initially ineligible for inclusion among the "connected" were organisations having fewer than 25 employees, this is not at all implausible.) Suppose then that the latter ratio was maintained between the average organisational outputs of the initially connected and the remaining unconnected, and further that by the end of 2008 the newly connected 0.176 ( $=0.4 \times .444$ ) of the total population --being those who were not eligible due to their small size -- attained 3.5 times the average output of the still unconnected group's average output, and therefore only half the multiple of the initially connected group. This would imply that the implied overall output-based extent of diffusion would have risen from 0.36 to 0.89 by 2008, but would have moved nearly to that level by 2006.

***Estimates of the effects of technology diffusion on the average pace of labor productivity growth:***

Having assembled all the pieces required the model (per equation (2)), we compute our estimate for the direct effect on the average growth rate of labor productivity over the period 2003 to 2006: it averages 2.9 percentage points per annum, whereas the corresponding rate for the period 2005 to 2008 is 1.6 percentage points per annum. The geometric average of the two gives the lower bound of the range reported in the text of Part II, section 1: an average growth rate of 2.2 percent per year.

To obtain an upper-bound for our estimated sector-wide labor productivity growth rate, we return to equation (1a) and note that by setting the parameter  $k = 1$  for the purpose of the foregoing calculation, the 2.2 percentage point per annum abstracts completely from the possibility that the diffusion process itself will induce enhancements of the productivity impacts of the new e-network technologies. Therefore, a computation of the full direct and indirect effect can be carried out simply by fixing the value for  $k = (1 - \epsilon) + \epsilon / \beta$ .

The previous calculations involved a pair of values for  $\beta$  based on two estimates for the magnitude  $1/\beta$ : the first was 3.77, which applied in the case of the connected organisations at and above the TDMC1 profile; the second was 8.25, which was applied to represent the situation pertaining among the organisations that were “unconnected” at the time of the 2003 survey. Their weighted average was put at  $1/\beta = 5.76$ . It remains, then, to fix the magnitude of the parameter  $\epsilon$ , which we may do by considering it to be the constant elasticity of a typical “learning curve”. In effect, this considers further improvements in the productivity differential associated with use of the new technology to derive from the accumulation of experience (or network externality effects) based upon the extent of its diffusion. The classic productivity-learning curve (the inverse of the usual unit cost reduction form of learning curve) in micro-level studies of industrial processes is found to have the value  $\epsilon = 0.33$ , implying that a doubling of the measure of experience would raise the level of average productivity by 25.7 percent.

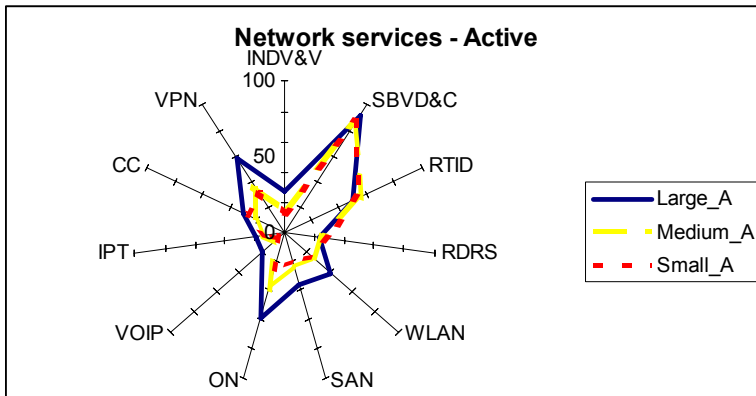
Using these two parameter values, the magnitude implied by the above formula is  $k = 2.57$ . Application of this multiplier to the calculated estimate of the direct effect of diffusion on the annual average aggregate labor productivity growth rate (2.2 percentage points) yields a corresponding *upper-bound* estimate of 5.6 percentage points for the whole period. The geometric average of the bounds reported by the text (at the conclusion of section 1 of Part II) is 3.5 percent per annum. It is interesting to note that the same average growth rate may be obtained by supposing that the indirect effects are felt only with a lag, during the period 2005-08, when the direct effect is reduced (to 1.6 percent p.a.). On that assumption, the growth rate for 2003-06 is the 2.9 percent per annum direct effect of diffusion, and the combined direct and indirect effects at 4.1 percent per annum during 2005-08. Their geometric average is 3.5 percent per annum.

### Addendum Figure A-II: 1 Diffusion Measures D(1) and D(3) for Specific Network Service Technologies, by Size Classes: Unweighted 8-Country Averages

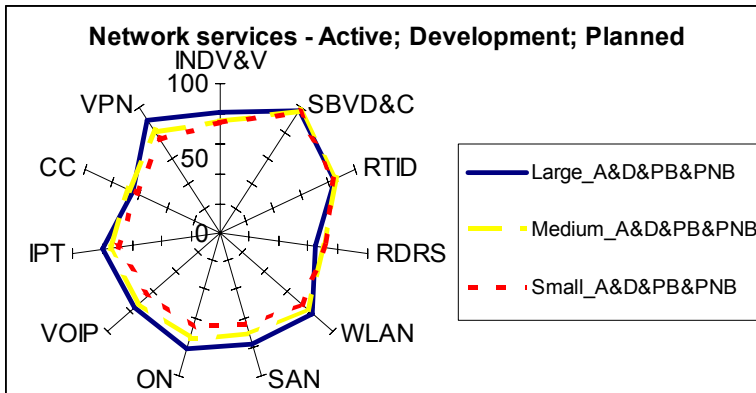
**NETWORK SERVICES**

- INDV&V – Integrated network for data, voice and video
- SBVD&C - Server-based virus detection and containment
- RTID – Real-time intrusion detection
- RDRS – Remote disaster recovery sites
- WLAN - Wireless LAN
- SAN - Storage area networks
- ON - Optical networking
- VOIP - Voice Over Internet Protocol
- IPT - Internet protocol telephony
- CC - Content caching
- VPN - Virtual private networks

**D(1): Average percentage of organisations currently having service active**



**D(3): Average percentage of organisations planning to have service active**



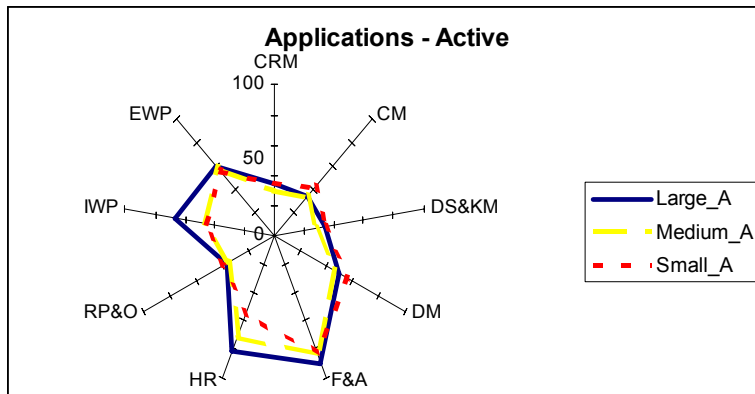
*Notes and Sources:* NI 2004 TDM survey responses for individual countries (all organisations) were tabulated to find the country-specific measures, which were then arithmetically averaged. See notes to Table II-1 and text discussion for definitions of the D(1) and D(3) measures.

## Addendum Figure A-II: 2 Diffusion Measures D(1) and D(3) for Specific Networked Applications Technologies, by Size Classes: Unweighted 8-Country Averages

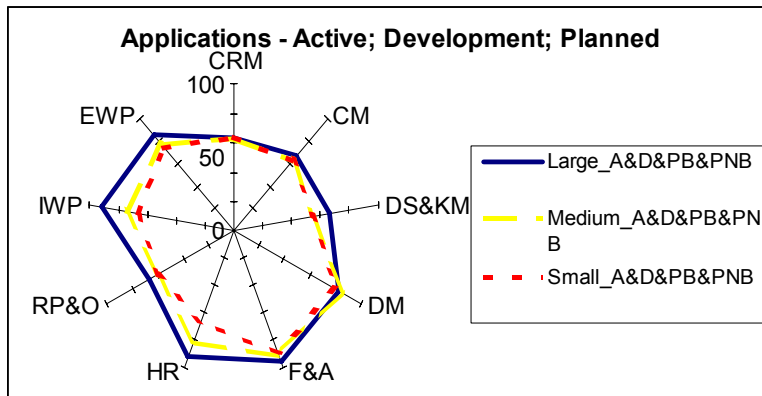
### NETWORKED APPLICATIONS

- CRM – Customer or citizen relationship management
- CM - Content management
- DS&KM – Decision support and knowledge management
- DM - Document management
- F&A - Finance and accounting
- HR - Human resources
- RP&O - Resource planning and optimization
- IWP - Internal web portals
- EWP - External web portals

### D(1): Average percentage of organisations currently having application active



### D(3): Average percentage of organisations planning to have application active



*Notes and Sources:* NI 2004 TDM survey responses for individual countries (all organisations) were tabulated to find the country-specific measures, which were then arithmetically averaged. See notes to Table II-1 and text discussion for definitions of the D(1) and D(3) measures.



## A-II.2 Results from Cluster Analysis of the TDM Data: e-Network Technology Profiles

The following tables describe the final cluster centers of the three clusters found in the individual organisation adoption data (a binary variable) for 9 specific network applications, 10 specific network services. Also shown are the final cluster centers of the cluster-triplet obtained from a binary transformation of the individual organisation's extent of deployment of networked applications, in which the organisation was scored according to whether the proportion of employees accessing the specific application was above or below the median proportion computed for that application from the observations on all organisations in the TDM sample.

**Table A-II.2:1 -- TDM CLUSTER ANALYSIS RESULTS: Network Applications (TNA)**

1 – Currently implemented; 0 – Otherwise

### Final Cluster Centers

	Cluster		
	TNA1	TNA2	TNA3
Implemented Customer or Citizen Relationship Management	1	0	0
Implemented Content Management	1	0	0
Implemented Decision Support and Knowledge Management	1	0	0
Implemented Document Management	1	0	0
Implemented Finance and Accounting	1	1	1
Implemented Human Resources	1	1	1
Implemented Resource Planning and Optimisation	1	0	0
Implemented Internal Web Portals	1	1	0
Implemented External Web Portals	1	1	0

### Number of Cases in each Cluster

Cluster	TNA 1	366
	TNA 2	332
	TNA 3	414
Valid	1112	
Missing	0	

**Table A-II.2: 2 -- TDM CLUSTER ANALYSIS RESULTS : Network Services (TNS)**

1 – Currently implemented; 0 – Otherwise

**Final Cluster Centers**

**Number of Cases in each Cluster**

	Cluster		
	TNS1	TNS 2	TNS 3
Implemented Integrated Network for Data, Voice and Video	0	0	1
Implemented Server-based Virus Detection and Containment	1	1	1
Implemented Real-time Intrusion Detection	0	1	1
Implemented Remote Disaster Recovery Sites	0	0	1
Implemented Wireless LAN	0	0	1
Implemented Storage Area Networks (SAN)	0	0	1
Implemented Optical Networking	0	0	1
Implemented Voice over Internet Protocol	0	0	0
Implemented Internet Protocol Telephony	0	0	1
Implemented Content Caching	0	0	1
Implemented Virtual Private Networks (VPN)	0	1	1

	<b>TNS1</b>	542
<b>Cluster</b>	<b>TNS2</b>	351
	<b>TNS3</b>	219
Valid		1112
Missing		0

**Table A-II.2:3 -- TDM CLUSTER ANALYSIS RESULTS: Networked Applications Deployment (TNAD)**

**Binary transformations of the relative extent of intra-organisational diffusion, based on:**

Customer or Citizen Relationship Management –	Median = 40% of workgroups
Content Management –	Median = 40% of workgroups
Decision Support and Knowledge Management –	Median = 20% of workgroups
Document Management –	Median = 60% of workgroups
Finance and Accounting –	Median = 20% of workgroups
Human Resources –	Median = 20% of workgroups
Resource Planning and Optimisation –	Median = 20% of workgroups

1 – Higher than the median; 0 – Lower than the median

**Final Cluster Centers**

	Cluster		
	TNAD1	TNAD2	TNAD3
Customer or Citizen Relationship Management over 40%	1	0	0
Content Management over 40%	0	0	0
Decision Support and Knowledge Management over 20%	0	0	0
Document Management over 60%	0	0	0
Finance and Accounting over 20%	0	1	0
Human Resources over 20%	0	1	0
Resource Planning and Optimisation over 20%	1	1	0

**Number of Cases in each Cluster**

Cluster	TNAD1	162
	TNAD2	229
	TNAD3	721
Valid	1112	
Missing	0	

### A-II.3 Distributions of TDM Sample Organisations Assigned to Clusters

The following 3 sets of tables shows the distributions of observations in the TDM sample by organisation type assigned among the cluster-triplets identified for each of the three dimensions of the e-network technology profile – as described by the above Tables A-II.2: 1,2 and 3. Selected panels are presented and discussed in the text of Part II.

**Table A-II.3:1 Assignment in Networked Applications (TNA) Clusters**

--- Organisation types within Clusters

<b>TDM:</b>					
		Network Applications: Cluster Number			Total
		TNA1	TNA2	TNA3	
Nat gov	Col %	4.4%	10.2%	3.4%	5.8%
R/L gov	Col %	46.2%	45.2%	49.8%	47.2%
Oth gov	Col %	2.5%	3.0%	2.9%	2.8%
Cli/Car	Col %	16.1%	8.7%	16.7%	14.1%
Ho/Lab	Col %	14.8%	18.7%	16.4%	16.5%
Oth he	Col %	12.6%	11.4%	8.0%	10.5%
Oth in/R	Col %	3.6%	2.7%	2.9%	3.1%
Total	Count	366	332	414	1112

--- Cluster Composition of Organisation Types

<b>TDM:</b>					
		Network Applications: Cluster Number			Total
		TNA1	TNA2	TNA3	
Nat gov	Row %	25.0%	53.1%	21.9%	100.0%
	Count	16	34	14	64
R/L gov	Row %	32.2%	28.6%	39.2%	100.0%
	Count	169	150	206	525
Oth gov	Row %	29.0%	32.3%	38.7%	100.0%
	Count	9	10	12	31
Cli/Car	Row %	37.6%	18.5%	43.9%	100.0%
	Count	59	29	69	157
Ho/Lab	Row %	29.3%	33.7%	37.0%	100.0%
	Count	54	62	68	184
Oth he	Row %	39.3%	32.5%	28.2%	100.0%
	Count	46	38	33	117
Oth in/R	Row %	38.2%	26.5%	35.3%	100.0%
	Count	13	9	12	34
Total	Row %	32.9%	29.9%	37.2%	100.0%
	Count	366	332	414	1112

**Table A-II.3:2 Assignments in Network Services (TNS) Clusters**

--- Organisation types within Clusters

<b>TDM:</b>					
		Network Services: Cluster Number			Total
		TNS1	TNS2	TNS3	
Nat gov	Col %	4.6%	6.3%	7.8%	5.8%
R/L gov	Col %	48.9%	46.7%	43.8%	47.2%
Oth gov	Col %	1.8%	3.4%	4.1%	2.8%
Cli/Car	Col %	15.5%	12.8%	12.8%	14.1%
Ho/Lab	Col %	16.8%	17.7%	14.2%	16.5%
Oth He	Col %	8.9%	10.5%	14.6%	10.5%
Oth in/R	Col %	3.5%	2.6%	2.7%	3.1%
Total	Count	542	351	219	1112

--- Cluster Composition of Organisation Types

<b>TDM:</b>					
		Network Services: Cluster Number			Total
		TNS1	TNS2	TNS3	
Nat gov	Row %	39.1%	34.4%	26.6%	100.0%
	Count	25	22	17	64
R/L gov	Row %	50.5%	31.2%	18.3%	100.0%
	Count	265	164	96	525
Oth gov	Row %	32.3%	38.7%	29.0%	100.0%
	Count	10	12	9	31
Cli/Car	Row %	53.5%	28.7%	17.8%	100.0%
	Count	84	45	28	157
Ho/Lab	Row %	49.5%	33.7%	16.8%	100.0%
	Count	91	62	31	184
Oth he	Row %	41.0%	31.6%	27.4%	100.0%
	Count	48	37	32	117
Oth in/R	Row %	55.9%	26.5%	17.6%	100.0%
	Count	19	9	6	34
Total	Row %	48.7%	31.6%	19.7%	100.0%
	Count	542	351	219	1112

**Table A-II.3:3 -- Assignments in Networked Applications Deployment Clusters (TNAD)**

--- Organisation types within Clusters

<b>TDM:</b>					
		Network Applications Deployment: Cluster Number			Total
		TNAD1	TNAD2	TNAD3	
Nat gov	Col %	9.3%	7.0%	4.6%	5.8%
R/L gov	Col %	42.0%	47.6%	48.3%	47.2%
Oth gov	Col %	1.9%	3.1%	2.9%	2.8%
Cli/Car	Col %	15.4%	12.2%	14.4%	14.1%
Ho/Lab	Col %	14.2%	13.5%	18.0%	16.5%
Oth he	Col %	14.2%	14.0%	8.6%	10.5%
Oth in/R	Col %	3.1%	2.6%	3.2%	3.1%
<b>Total</b>	<b>Count</b>	162	229	721	1112

--- Cluster Composition of Organisation Types

<b>TDM:</b>					
		Network Applications Deployment: Cluster Number			Total
		TNAD1	TNAD2	TNAD3	
Nat gov	Row %	23.4%	25.0%	51.6%	100.0%
	Count	15	16	33	64
R/L gov	Row %	13.0%	20.8%	66.3%	100.0%
	Count	68	109	348	525
Oth gov	Row %	9.7%	22.6%	67.7%	100.0%
	Count	3	7	21	31
Cli/Car	Row %	15.9%	17.8%	66.2%	100.0%
	Count	25	28	104	157
Ho/Lab	Row %	12.5%	16.8%	70.7%	100.0%
	Count	23	31	130	184
Oth he	Row %	19.7%	27.4%	53.0%	100.0%
	Count	23	32	62	117
Oth in/R	Row %	14.7%	17.6%	67.6%	100.0%
	Count	5	6	23	34
<b>Total</b>	Row %	14.6%	20.6%	64.8%	100.0%
	Count	162	229	721	1112

#### A-II.4 Meta-Cluster Analysis Results based on the TDM Adoption Data and the Resulting “Technology Profile” Distributions of Organisations by Type

Table A-II.4:1 The Technology Profiles Corresponding to the Five “Meta-Clusters”

Final Cluster Centers from Meta-Cluster Analysis

	<b>META-CLUSTER</b>				
<b>Technology Profile Rankings (Ascending)</b>	<b>1</b>	<b>2</b>	<b>3.5</b>	<b>3.5</b>	<b>5</b>
Meta-Cluster Numbers	<b>TMC1</b>	<b>TMC4</b>	<b>TMC5</b>	<b>TCM3</b>	<b>TCM2</b>
<b>Networked Applications Profile (Ascending Ranks)</b> TNA Cluster Numbers	<b>1</b> TNA3	<b>1</b> TNA3	<b>3</b> TNA1	<b>2</b> TNA2	<b>3</b> TNA1
<b>Network Services Profile (Ascending Ranks)</b> TNS Cluster Numbers	<b>1</b> TNS1	<b>2</b> TNS2	<b>2</b> TNS2	<b>1</b> TNS1	<b>3</b> TNS3
<b>Network Applications Deployment Profile (Ranks)</b> TNAD Cluster Numbers	<b>1</b> TNAD3	<b>1</b> TNAD3	<b>1</b> TNAD3	<b>3</b> TNAD1	<b>2</b> TNAD2
<b>Network Applications Support (Supra-median) (Ranks)</b> NA_SUPP Dummy Variable	<b>1</b> 0	<b>2</b> 1	<b>2</b> 2	<b>2</b> 2	<b>2</b> 2
<b>WAN Connected (Rank)</b> NOT_WAN Dummy Variable	<b>1</b> 0	<b>1</b> 0	<b>1</b> 0	<b>1</b> 0	<b>1</b> 2

Table A-II.4:2 -- Assignments of TDM Survey Organisations to e-Network "Meta-Clusters"

## --- Organisation types within Meta-Clusters

TDM:							
		Meta-Clusters: Cluster Number					Total
		TMC1	TMC2	TMC3	TMC4	TMC5	
Nat gov	Col %	4.9%	<b>10.8%</b>	<b>7.4%</b>	4.2%	3.8%	5.8%
R/L gov	Col %	<b>50.6%</b>	45.2%	43.2%	48.9%	45.5%	47.2%
Oth gov	Col %	1.8%	<b>3.0%</b>	2.5%	2.6%	<b>4.1%</b>	2.8%
Cli/Car	Col %	13.4%	9.6%	<b>17.3%</b>	<b>19.5%</b>	12.0%	14.1%
Ho/Lab	Col %	17.7%	10.2%	16.7%	15.8%	<b>19.5%</b>	16.5%
Oth he	Col %	8.2%	18.1%	11.1%	6.8%	10.9%	10.5%
Oth in/R	Col %	3.4%	3.0%	1.9%	2.1%	<b>4.1%</b>	3.1%
All	Count	328	166	162	190	266	1112

**Note:** Boldface entries indicate over-representedness of the type within the meta-cluster, relative to its frequency in the TDM sample.

## --- Meta-Cluster Composition of Organisation Types

TDM:							
		Meta-Clusters: Cluster Number					Total
		TMC1	TMC2	TMC3	TMC4	TMC5	
Nat gov	%	25.0%	28.1%	18.8%	12.5%	15.6%	100.0%
R/L gov	Cou	16	<b>18(9.0)</b>	12	8	10	64
Oth gov	%	19.4%	16.1%	12.9%	16.1%	35.5%	100.0%
Cli/Car	Cou	<b>166(78)</b>	75	70	93	121	525
Ho/Lab	%	31.5%	9.2%	14.7%	16.3%	28.3%	100.0%
Oth he	Cou	6	5	4	5	<b>11(7.4)</b>	31
Oth in/R	%	28.0%	10.2%	17.8%	23.6%	20.4%	100.0%
All	Cou	44	16	28	<b>37(26.8)</b>	32	157
	%	31.5%	9.2%	14.7%	16.3%	28.3%	100.0%
	Cou	58	17	27	30	<b>52(44)</b>	184
	%	23.1%	25.6%	15.4%	11.1%	24.8%	100.0%
	Cou	27	<b>30(17.5)</b>	18	13	29	117
	%	32.4%	14.7%	8.8%	11.8%	32.4%	100.0%
	Cou	11	5	3	4	<b>11(8.1)</b>	34.
All	%	29.5%	14.9%	14.6%	17.1%	23.9%	100.0%
	Cou	328	166	162	190	266	1112

**Note:** In the above table the **boldfaced** entries compare the observed number of organisations with the number that would be expected if organisations had been assigned independently on the basis of the relative frequency distributions of cluster size and organisation types, as indicated by the marginal totals.



## ADDENDA TO PART III

Table A-III:1

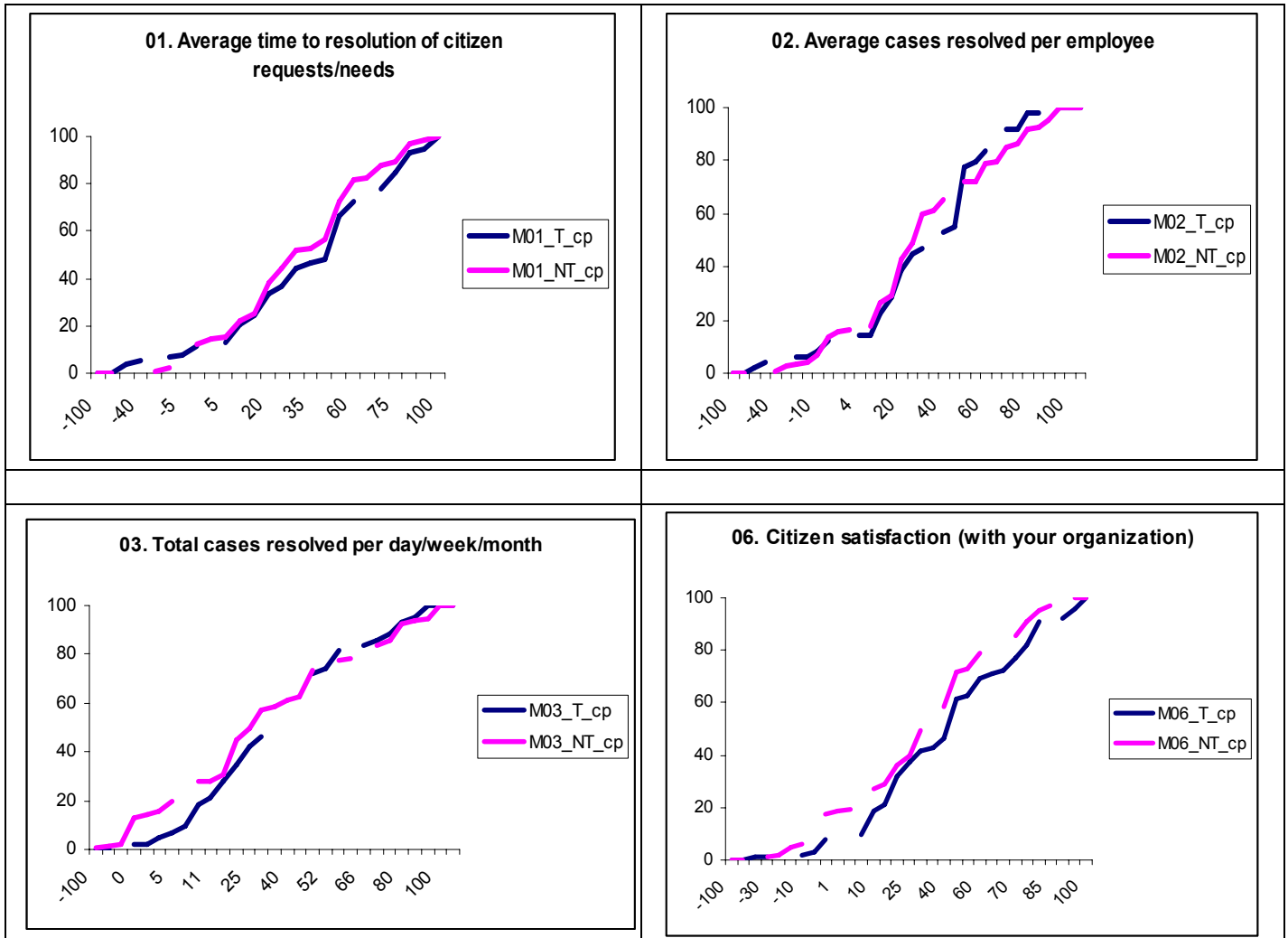
**BDM's Estimates of Percentage Change in Their Organisation's Performance:  
Distribution Statistics of Organizations that Do and Do Not Track the Metric**

PERFORMANCE METRICS GROUPED BY ORGANISATION FUNCTION	Tracked			Not Tracked		
	<u>Mean</u>	<u>Median</u>	<u>Range</u>	<u>Mean</u>	<u>Median</u>	<u>Range</u>
<b>Client-Customer Service Quality:</b>	<b>42.24</b>			<b>36.60</b>		
01. Average time to resolution of citizen requests/needs	40.13	50.00	150	36.95	30.00	120
06. Citizen satisfaction (with your organization)	44.34	50.00	140	36.24	40.00	130
<b>Citizen/Client Access and Service Usage:</b>	<b>36.97</b>			<b>32.14</b>		
04. Number of citizens using the service	37.36	30.00	100	34.43	30.00	200
05. Percent of cases resolved through self-service	26.19	20.00	70	29.81	20.00	200
10. Number of visitors to organizational portal / website	45.50	45.00	170	38.57	30.00	150
11. Number of cases / requests filed online	39.55	30.00	100	27.15	20.00	200
12. Percent of relevant services available online	36.25	27.50	100	30.73	20.00	200
<b>Task Productivity Metrics:</b>	<b>39.57</b>			<b>29.86</b>		
02. Average cases resolved per employee	33.45	40.00	175	34.57	30.00	140
03. Total cases resolved per day/week/month	40.65	50.00	100	34.91	27.50	200
08. Average cost per case resolution	38.61	35.00	90	20.10	10.00	105
<b>Financial-Accounting Metrics:</b>	<b>22.77</b>			<b>25.66</b>		
07. Annual operating costs	20.60	15.00	130	23.08	20.00	200
09. Annual fees or revenue collected	24.93	20.00	115	28.23	20.00	200

**Source:** Calculated from responses of Business Decision Managers in the 283 organisations of the BDM Survey conducted for the NI 2004 Report. Non-responses (Don't Know; Refused) were not counted.

**Figs. A-1 Cumulative Distributions of Perceived “Impacts” for Selected Metrics, Comparing Organisations that Did and Did Not Track the Metric**

BDM’s “impact” estimates (percentage changes in the metric during the past year) is on the abscissa  
 Key: T= Organisations that Tracked ; NT = Organisations that Did Not Track



**Comment:** The plot of the cumulative distribution shows the proportion of responses that are equal to or less than the percentage indicated on the horizontal axis. Note that the horizontal scales are not arithmetic, and are not uniform across the metrics shown. Comparisons within each frame, however, remain valid. Taking the tracking organisations as the reference, when the light blue lies above the dark blue line, this implies that the non-tracking responses are biased downwards, and upwards when the dark blue line lies above the light blue line.

## Selected Explanatory Variables and Regression Results

**TABLE A-III.2**

End Output of Final-Final BDMM final regression results with TDM meta-cluster, and Organisation Type and Country controls

--- Meta-cluster cases in the BDMM Sample are from the results of the meta-cluster analysis on the TDM Sample

--- Estimation of the (Restricted) Extended Model, with Organisation Type and Country Effects (Restricted)

---

### **1. Estimated Improvements in Citizen Case Resolution Time**

**LNImp01T-F2 = f(Constant, Integrbp, Germany, Sweden) --- Reference group: Italy and Government (and no datamin and integrbp).**

	Coefficients		t	Sig.
	Estimate	Std. Error		
(Constant)	3.752	.106	35.338	.000
INTEGRBP	.571	.163	3.496	.001
GERMANY	-.742	.191	-3.877	.000
SWEDEN	-.801	.209	-3.835	.000

#### ANOVA

	Sum of Squares	Df	Mean Square	F	Sig.
Regression	14.088	3	4.696	14.660	.000
Residual	18.258	57	.320		
Total	32.345	60			

Note: Restriction of LNImp01T\_F omitted Spain and Poland

#### **Model Summary <sup>a</sup>**

Model	R	R Square	Adjusted R Square
III.2.1	.660(a)	.436	.406

a Predictors: Constant, Integrbp, Germany, Sweden

TABLE A-III.2, continued

**2. Estimated Improvements in Number of Cases Resolved per Employee**

$\text{LnImp02T-F2} = f(\text{Constant, tdmc3, tdmc3int, health})$  --- Reference group: Italy and Government (and no tdmc3, integrbp and tdmc3int).

	Coefficients		T	Sig.
	Estimate	Std. Error		
(Constant)	3.778	.127	29.786	.000
TDMC3	-1.017	.297	-3.424	.001
TDMC3INT	1.640	.519	3.161	.003
HEALTH	-.501	.210	-2.388	.022

**ANOVA**

	Sum of Squares	Df	Mean Square	F	Sig.
Regression	7.678	3	2.559	6.698	.001
Residual	14.521	38	.382		
Total	22.199	41			

Note: Restriction of LNImp01T\_F omitted Spain and UK

**Model Summary<sup>a</sup>**

Model	R	R Square	Adjusted R Square
III.2.2	.588(a)	.346	.294

a Predictors: Constant, tdmc3, tdmc3int, health

### 3. Estimated Improvements in Citizen Satisfaction

$\text{LnImp06T-F2} = f(\text{Constant, tdmc4, tdmc5, Integrbp, tdmc5ctr, Germany})$  --- Reference group: Italy and Government (and no tdmc4, tdmc5, datamin, integrbp and tdmc5ctr).

	Coefficients		T	Sig.
	Estimate	Std. Error		
(Constant)	3.773	.112	33.605	.000
TDMC4	-.244	.172	-1.418	.160
TDMC5	-.538	.200	-2.698	.009
INTEGRBP	.335	.151	2.222	.029
TDMC5CTR	.714	.339	2.104	.039
GERMANY	-1.132	.265	-4.275	.000

#### ANOVA

	Sum of Squares	Df	Mean Square	F	Sig.
Regression	16.520	5	3.304	7.840	.000
Residual	33.715	80	.421		
Total	50.235	85			

#### Model Summary<sup>a</sup>

Model	R	R Square	Adjusted R Square
III.2.3	.573(a)	.329	.287

a Predictors: Constant, tdmc4, tdmc5, Integrbp, tdmc5ctr, Germany

TABLE A-III.3

**NI 2004 REPORT'S SELECTION OF "BEST PRACTICE" VARIABLES :  
DEFINITIONS & SOURCES**

***Regression 01--DEPENDENT VARIABLES (Imp 01; LN\_Imp01 )***

**METRIC 01: "Average time to resolve client request/needs"**

**REGRESSORS FOR THE EXTENDED MODEL**

(Observations on the variables derived from *NI 2004*: BDM Questionnaire, unless noted TDM

**Business Process**

**(DATAMIN)**

. Data mining and Analysis Supported by Network Wide Applications  
TDM Q4.2 (if Yes then DUMMY = 1)

**(CASEMNGT)**

. Case management Internet Connected ( Q2b CM If yes DUMMY = 1)

**(SERVDEL)**

. Service Delivery Internet Connected (Q2c: SD If yes DUMMY = 1)

**(AUTOBPCM)**

. Business Process Automation :Q1b BPA Case Management (If yes DUMMY = 1)

**(AUTOBPSD)**

. Business Process Automation : Q1c BPA Service Delivery (If yes DUMMY = 1)

**(INTEGRBP)**

. Business Process Integration : Q15b (if 6 or 7 then DUMMY = 1)

**Organisational Culture and Behavior**

**(ORGWIDED)**

. Technology enabled services are uniformly deployed organisation wide  
TDM Q9a (if 6 or 7 then DUMMY = 1)

TABLE A-III.3, continued

## NI 2004 REPORT'S SELECTION OF "BEST PRACTICE" VARIABLES

**Regression 02--DEPENDENT VARIABLES (Imp 02; LN\_Imp02 )****METRIC 02: "Average cases resolved per employee"****REGRESSORS FOR THE EXTENDED MODEL**

Observations on the variables derived from *NI 2004*: BDM Questionnaire, unless noted TDM

**Business Process****(DATAMIN)**

- . Data mining and Analysis Supported by Network Wide Applications  
TDM Q4.2 (if Yes then DUMMY = 1)

**(CASEMNGT)**

- . Case management Internet Connected ( Q2b CM If yes DUMMY = 1)

**(SERVDEL)**

- . Service Delivery Internet Connected (Q2c: SD If yes DUMMY = 1)

**(AUTOBPCM)**

- . Business Process Automation :Q1b BPA Case Management (If yes DUMMY = 1)

**(AUTOBPSD)**

- . Business Process Automation : Q1c BPA Service Delivery (If yes DUMMY = 1)

**(INTEGRBP)**

- . Business Process Integration : Q15b (if 6 or 7 then DUMMY = 1)

**Organisational Culture and Behavior****(ORGWIDED)**

- . Technology enabled services are uniformly deployed organisation wide  
TDM Q9a (if 6 or 7 then DUMMY = 1)

TABLE A-III.3, continued

## NI 2004 REPORT'S SELECTION OF "BEST PRACTICE" VARIABLES

*Regression 03--DEPENDENT VARIABLES (Imp 06; LN\_Imp06 )*METRIC 06: "Citizen satisfactions with the organisation's service "

## A PRIORI LIST OF REGRESSORS FOR THE EXTENDED MODEL

Observations on the variables derived from *NI 2004*: BDM Questionnaire, unless noted TDM

**Business Process****(DATAMIN)**

- . Data mining and Analysis Supported by Network Wide Applications:  
TDM Q4.2 (if Yes then DUMMY = 1)

**(AUTOWKTR)**

- . Automating Workforce Collaboration and Training:  
Q1g (if >40% then DUMMY = 1)

**(AUTOBPSD)**

- . Automating Service Delivery: Q1c BPA Service Delivery (If yes DUMMY = 1)

**(PROBDIAG)**

- . Problem Diagnosis and Resolution: Q1e (If yes DUMMY = 1)

**Organisational Culture and Behavior****(CTRSTRAT)**

- . Organisational strategic IT plan communicated throughout organisation:  
Q15a (if 6 or 7 then DUMMY = 1)

**(PREREENG)**

- . Re-engineered business processes before implementing network applications:  
Q8 (if 1=1 then DUMMY = 1)

**(REENGINEER\_WITH)**

- . Re-engineered business process in response to implementing new network applications: Q8 (if 2=1 then DUMMY = 1)

**(ITDEPCOO)**

- . IT Department works closely with organisational leaders:  
Q9p (if 6 or 7 then DUMMY = 1)