WORKING PAPERS AND STUDIES



Luxembourg: Office for Official Publications of the European Communities, 2004

ISBN 92-894-7246-4
ISSN 1725-0684
Cat. No. KS-DE-04-001-EN-N



2004 EDITION

# e-Commerce and firm performance

## An assessment using multiple survey sources and linked data

4

EUROPEAN COMMISSION

eurostat

THEME 4
Industry, trade and services

*Europe Direct is a service to help you find answers to your questions about the European Union*

**New freephone number:**
**00 800 6 7 8 9 10 11**

A great deal of additional information on the European Union is available on the Internet.
It can be accessed through the Europa server (http://europa.eu.int).

Luxembourg: Office for Official Publications of the European Communities, 2004

ISSN 1725-0684
ISBN 92-894-7246-4

# e-Commerce and Firm Performance

## An assessment using multiple survey sources and linked data

Report to the European Commission (DG Eurostat and DG Enterprise)

Authors: Tony Clayton, Chiara Criscuolo, Peter Goodridge

## Contents

1. Introduction and summary
2. Objectives of research
3. Data sources used
4. Summary of statistical results
5. e-Commerce adoption evidence
6. Productivity in manufacturing
7. Price effects
8. Service sector; retailing and stocks
9. R&D and innovation
10. Conclusions and next steps

With grateful acknowledgements to Kathryn Waldron, Misha Tsvelik and members of the ONS / Ceriba Business Data Linking team for support on analytical work, and to Debra Prestwood, Andrew Walton, Ray Lambert, Andrew Allen and Sue Smith for access to, and advice on data.

Office for National Statistics July 2003

# INDEX

**1. Introduction and summary**
*1.1 Research Framework*
*1.2 Conclusions on e-Commerce Impacts*
*1.3 Conclusions on Methodology and Surveys*

**2. Objectives of research**
*2.1 Initial approach*
*2.2 How the approach developed during research*
*Table 2.1 Observation numbers in each data set and the overlaps*

**3. Data sources used for economic analysis**
*3.1 Annual Business Inquiry*
*Figure 3.1 E-commerce question format*
*3.2 Community Innovation Survey*
*Figure 3.2 Linear innovation model*
*3.3 Producer Price Inquiry*
*3.4 e-Commerce survey*
*Figure 3.3 Data summary from surveys*
*3.5 Capital Investment Surveys*

**4. Summary of statistical results**
*4.1 e-Commerce adoption*
*4.2 Productivity in manufacturing*
*4.3 Price effects*
*4.4 Service sector; retailing and stocks*
*4.5 R&D and innovation*

**5. e-Commerce adoption evidence**
*5.1 Background*
*5.2 Technology infrastructure in firms*
*Figure 5.1 Distribution of 'connected' technologies in firms*
*Figure 5. 2 Technology combinations and e-commerce activity*
*5.3 Rate and distribution of adoption*
*Figure 5.3 Year of adoption of network technologies by sizeband*
*Figure 5.4 e-commerce sales as % of turnover, by sizeband*
*Figure 5.5 Business % e-commerce sales via internet, and all e- networks, 2000*
*Figure 5.6 Business % e-commerce sales via internet, and all e- networks, 2001*
*5.4 Sector balance of e-purchasers and e-sellers*
*Table 5.1 e-Purchasers vs. e-Sellers*
*5.5 Perceived business benefits of e-commerce*
*Figure 5.7 Specific benefits vs. first year selling over e-networks*
*Figure 5.8 'Marketing' benefits vs. first year selling over e-networks*
*5.6 Leads and lags*
*Figure 5.9 e-Activity vs. time with a connected technology*
*5.7 Entry and exit*
*Table 5.2 2000/2001 responses linked; % sales over all networks*

**6. Productivity in manufacturing**
*6.1 Background to selection of approach*
*6.2 Regression analysis*
*6.3 Interpreting the regression results*
*6.4 Interpreting the data*
*Figure 6.1 Value added / employee vs. e-commerce activity*
*Table 6.1 Regression results, 2000*
*Table 6.2 Regression results, 2000 - 2001*
*Table 6.3 Regression results, 2000 - 2001, smaller firms*
*Table 6.4 Regression results, 2000 - 2001, larger firms*
*Table 6.5 Descriptive statistics 2000 - 2001*
*Table 6.6 Distribution of observations by sector 2000 - 2001*
*Figure 6.2 Value added / employee by SIC sector, 2000*

**7. Price effects**
*7.1 Outline*
*7.2 Firm discussions*
*7.3 Evidence from other sources*
*7.4 UK survey data*
*7.5 Conclusions*
*Table 7.1 Regression results for effect of e-selling on producer prices*
*Table 7.2 Sectors covered by analysis*
*Figure 7.1 SICs 1513 and 1581*
*Figure 7.2 SICs 2852 and 2442*
*Figure 7.3 SICs 2414 and 2420*
*Figure 7.4 SICs 3210 and 2212*
*Figure 7.5 SICs 24511 and 3430*
*Figure 7.6 SICs 2430*

**8. Service sector; retailing and stocks**
*8.1 Labour Productivity in Services*
*8.2 Retail productivity*
*Table 8.1 SIC 52.1 Retail sale in non-specialised stores*
*Table 8.2 SIC 52.2 Retail sale of food, beverages and tobacco; specialised stores*
*Table 8.3 SIC 52.3 Retail sale of pharmaceutical and medical goods, etc*
*Table 8.4 SIC 52.4 Other retail sale of new goods in specialised stores*
*Table 8.9 Productivity across SIC 52 (2000)*
*Table 8.10 Productivity across SIC 52 (2001)*
*Table 8.11 Size (employment) and e-commerce*
*8.3 Retail Stocks*
*Table 8.19 SIC 52.1 Retail sale in non-specialised stores*
*Table 8.20 SIC 52.2 Retail sale of food, beverages and tobacco;specialised stores*
*Table 8.21 SIC 52.3 Retail sale of pharmaceutical and medical goods,*
*Table 8.22 SIC 52.4 Other retail sale of new goods in specialised stores*
*Table 8.27 Stock ratios - SIC 52 Retail (2000)*
*Table 8.28 Stock ratios - SIC 52 Retail (2001)*
*Table 8.29 Stock ratios - SIC 52 Retail (2000) by size and e-activity*
*8.4 Conclusions*
*Figure 8.1: Value added / employee, 2000, service industries*
*Appendix A Regression Analysis*

*Annexe to section 8; Size and sector - productivity;*
*Table 8.5 SIC 52.1 Retail sale in non-specialised stores*
*Table 8.6 SIC 52.2 Retail sale of food, beverages and tobacco in specialised stores*
*Table 8.7 SIC 52.3 Retail sale of pharmaceutical and medical goods, etc.*
*Table 8.8 SIC 52.4 Other retail sale of new goods in specialised stores*
*Sector and e-commerce effects*
*Table 8.12 SIC 52.1 Retail sale in non-specialised stores*
*Table 8.13 SIC 52.2 Retail sale of food, beverages and tobacco in specialised stores*
*Table 8.14 SIC 52.3 Retail sale of pharmaceutical and medical goods,*
*Table 8.15 SIC 52.4 Other retail sale of new goods in specialised stores*
*Sector, size and e-commerce effects*
*Table 8.16 SIC 52.1 Retail sale in non-specialised stores*
*Table 8.17 SIC 52.2 Retail sale of food, beverages and tobacco in specialised stores*
*Table 8.18 SIC 52.4 Other retail sale of new goods in specialised stores*
*Stock trends by sector / size*
*Table 8.23 SIC 52.1 Retail sale in non-specialised stores*
*Table 8.24 SIC 52.2 Retail sale of food, beverages and tobacco in specialised stores*
*Table 8.25 SIC 52.3 Retail sale of pharmaceutical and medical goods,*
*Table 8.26 SIC 52.4 Other retail sale of new goods in specialised stores*
*Stocks, e-commerce effects by sector*
*Table 8.30 SIC 52.1 Retail sale in non-specialised stores*
*Table 8.31 SIC 52.2 Retail sale of food, beverages and tobacco in specialised stores*
*Table 8.32 SIC 52.3 Retail sale of pharmaceutical and medical goods*
*Table 8.33 SIC 52.4 Other retail sale of new goods in specialised stores*
*Stocks, e-commerce, sector and size*
*Table 8.34 SIC 52.1 Retail sale in non-specialised stores*
*Table 8.35 SIC 52.4 Other retail sale of new goods in specialised stores*

**9. R&D and innovation**
*9.1 Background*
*9.2 Models for R&D and Innovation*
*9.3 Studies based on UK CIS*
*9.4 Tabulations based on CIS3*
*9.5 R&D => Innovation*
*Figure 9.1 Innovation vs relative 'intellectual capital' R&D expenditure*
*Figure 9.2 Innovation vs relative innovation related expenditure*
*9.6 Innovation => output growth*
*Figure 9.3 Relative growth vs relative innovation - manufacturing*
*Figure 9.4 Relative growth vs relative innovation - services*
*9.7 e-Business effects and the linear model*
*9.8 Electronic networks and collaboration*
*Figure 9.5 Collaboration section of CIS questionnaire*

**10. Conclusions and next steps**

# 1 Introduction and Summary

*1.1 Research Framework*

This report draws together work undertaken in ONS up to June 2002/3 to investigate the ways in which the use of electronic networks by firms affects their behaviour and performance. In undertaking these studies we have built upon progress made elsewhere, both in measurement techniques for use of ICT and e-commerce, and in analysis of the data from resulting surveys. We owe a great deal to:

- progress made by Eurostat and OECD in defining common approaches to measurement and enterprise surveys covering ICT use
- definitions of e-commerce developed by OECD, and applied in Eurostat's work
- the international exchanges coordinated by OECD during 2002 on ICT impact work, and brought together in their forthcoming ministerial report.

The purpose of the research is to investigate how far data collected in Eurostat based surveys on the information society (the enterprise e-commerce survey) can be linked with those on structural business statistics (the annual business inquiry for the UK) and on innovation (the community innovation survey) to develop methodologies and deliver conclusions on the economic impact of e-commerce. In doing this, we have analysed

- the scope for linking between the various surveys, and the possible value of other sources for this type of work
- practical possibilities for obtaining statistically valid results from linked data
- conclusions from structural business statistics on productivity, using qualitative questions, and the implications these appear to have for pricing
- feasibility of analysing effects of electronic business processes on logistics (as measured by stocks) using e-commerce questions linked to structural business statistics in the retail sector
- possible models for electronic business processes to impact on innovation outputs.

*1.2 Conclusions on e-Commerce Impacts*

The main conclusions from the programme of work to date are that:

- e-commerce survey results from the first two rounds of UK surveys show a high level of experimentation, entry and exit in electronic markets, and the sampling issues make overlap with the structural business statistics too small to generate statistically robust conclusions on firm performance (early indications from the third round suggest more stability)
- the e-commerce surveys do, however give valuable conclusions on the adoption of ICT and e-business processes, which inform research using other sources
- productivity effects of e-commerce from the much larger manufacturing samples available from the ABI give robust results for both 2000 and 2001, but show effects which are more complex than the simple 'production function' modelling which has been used in much of the macro and micro work to date
- in addition to 'efficiency effects' from e-commerce use which appears to be significant in statistical analysis of gross output in the manufacturing sector, there are much more pronounced price effects which are visible in analysis of value added which discriminate between the gains and losses to buyers and sellers
- in the majority of manufacturing sectors we have examined in detail (by linking firm level e-commerce use to price evolution as detected in price surveys) it appears that increased competition due to electronic trading exerts a restraining influence on prices, changing the

distribution of value added between buyers and sellers, and this affects the ability to detect productivity gains from ICT at firm level

- the impact of electronic transactions differs across manufacturing sectors, and can be very different in services; in retailing for example, the gains and losses associated with buying / selling appear the reverse of manufacturing, and apparent effects on stocks are unexpected
- while the analysis of innovation has failed to show significant benefits associated with e-commerce, this is in part due to methodological issues associated with measurement of the innovation process, and the limitations of initial data in both innovation and e-commerce
- the model suggested in our original proposal for innovation leading to enterprise growth and productivity gains is partly supported by this, and other, research; however the possible effects of electronic business processes in it are more likely to be connected with enhancing collaboration between firms than directly with access to markets

Perhaps the most important conclusion of work to date is that the most visible effect of electronic networks on business behaviour and performance in our data is not due to internal efficiency gains or shifts in production functions. Instead it shows up in changes to the way markets work. The evidence in this research, which for the first time splits the impact of buying and selling in electronic markets, shows how e-commerce has influenced market efficiency.

Taken together with case evidence from firms which have used electronic networks for procurement, it is consistent with assertions that reduction in search costs in electronic markets, the broadening of potential supply and the increased transparency of price and non-price factors have reduced 'friction' in markets. In manufacturing sectors where there is typically scope for buyers to make comparisons this is more likely than not to exert downward pressure on prices

In the longer term, more efficient markets may speed up selection processes by which efficient producers replace the less efficient. But in the early stages of business adoption of buying and selling through electronic networks, the strongest statistical findings appear to be related to the efficiency of markets themselves. Therefore, to assemble evidence for productivity effects from ICT and e-business it is necessary to look at other output measures in addition to value added.

*1.3 Conclusions on Methodology and Surveys*

A general, conclusion from the work on data linking contained in this project is that overlaps between surveys restrict what can be achieved. Adequate coverage in overlapping samples is only achieved for larger firms, sampled at or close to the 100% level in at least one of the surveys linked. This problem may diminish as a longer panel of surveys is achieved, but even this is unlikely to give sufficient overlap data on smaller enterprises, typically sampled at low frequency, and therefore unlikely to appear in two separate surveys. The approach used by ISTAT - to add e-commerce questions to the structural business survey - seems the best approach to tackle SMEs.

Another pointer from this work is the need to look beyond electronic buying and selling. It is clear from our limited conclusions on innovation and logistics that links between firms that do not involve buying and selling transactions affect behaviour. The current Eurostat survey, as applied in the UK in 2001/2 and 2002/3 captures e-business processes which are linked through e-commerce links; work on assessing their associations with productivity are under way. Results from the US Bureau of Census Computer Network Use survey suggests that electronic links through e-commerce represent less than half of the links in use. Developing effective measures of wider e-business links is a challenge which EU surveys have yet to complete.

# 2 Objectives of Research

## *2.1 Initial approach*

This project was designed as pilot research to investigate the feasibility of linking micro data from:

- surveys used to produce structural business statistics (the Annual Business Inquiry or ABI)
- the Eurostat designed e-commerce inquiry
- other surveys including the Community Innovation Survey (CIS)

Results from each of these surveys is reported separately by ONS or DTI, and the scope for micro-data linking with the financial and employment data in the ABI is discussed fully in ONS publications (Barnes and Martin 2002). The purpose of linking data at business level is to establish whether statistical evidence shows:

- links between e-commerce activity, ICT use , innovation, and business growth
- links between e-commerce use and labour productivity
- links between e-commerce use and working capital productivity
- whether e-commerce users are more effective innovators than non-users

Development of methodology in this area is seen in the UK as an important element in analysiing ICT impact in the economy, to assist policy management. To date UK based work on ICT productivity effects has been based on growth accounting studies at sector level (see London Economics study, 2003, and Oulton 2001). By identifying how ICT and e-commerce adoption affects business behaviour and performance at the enterprise level, the use of survey data to assess policy impact for the Information Economy should be made more effective.

The initial aim was to build as many links as possible between data-sets on output, innovation, e-commerce, ICT use, and to test integrated models using all of them simultaneously. This proved to be possible in some areas of statistical analysis, but not for the e-commerce survey, partly because of sample overlap issues and partly because of the high rate of entry and exit the survey itself shows from 2000 to 2001.

## *2.2 How the approach developed during research*

As the initial multiple linking approach - although practical - did not yield samples of businesses large enough for statistically significant results for parts of the work, an alternative was developed using linked analysis, based on single data-sets, or in some cases two linked data-sets. For example:

- the e-commerce survey has been used to explore the relationships between ICT use and business take-up of e-commerce
- the ABI has been used, taking advantage of questions on e-commerce use included in 2000 and 2001, for analysis of productivity.

However, linking has proved essential to achieve certain results. To analyse how far effects of e-buying revealed by analysis were due to price changes, we have taken data from ONS' producer price inquiry (PPI) series and separated it according to whether firms providing the original price data were actively selling through electronic networks or not. The identification of reporting units to do this was achieved through the UK business register, on the basis of responses to the ABI survey, rather than the smaller e-commerce survey for which the overlap sample with the PPI data-set would have been too small.

It is in the area of innovation that linking has proved most difficult, because of overlap problems with multiple surveys. While a substantial amount of work on innovation and productivity has been achieved by researchers at ONS using linkage between CIS and ABI, the additional three way link to the e-commerce survey has led to unworkably small samples. To get statistically workable data to relate e-commerce to innovation it has been necessary to use the internet usage questions from the innovation survey itself.

Even for work on e-commerce and output data, the ABI source has proved more effective as a source of e-commerce use data because, as shown below, the ARD / e-commerce overlap provides only 707 linked observations, while the ABI data even after accounting for problematic or incomplete e-commerce items provides over 7000.

The overlaps between ABI, CIS and e-Commerce surveys for 2000 are as follows:

**Table 2.1 Observation numbers in each data set and their overlaps**

| | | ARD (SEL) | E-COM | CIS3 | ARD+ E-COMM | ARD + CIS3 | ARD+CIS 3 + E-COMM |
|---|---|---|---|---|---|---|---|
| | ALL SECTORS | 53,197 | 7,318 | 8,172 | 1,928 | 3,467 | 380 |
| SIC CODE | DISTRIBUTION BY SECTOR | | | | | | |
| A | AGRICULTURE, HUNTING AND FORESTRY | 75 | n/a | n/a | n/a | n/a | n/a |
| B | FISHING | 92 | n/a | n/a | n/a | n/a | n/a |
| C | MINING AND QUARRYING | 297 | n/a | 127 | n/a | 81 | n/a |
| D | MANUFACTURING | 11,696 | 2703 | 3,440 | 707 | 1625 | 140 |
| E | ELECTRICITY, GAS AND WATER SUPPLY | 105 | 48 | 53 | 39 | 41 | 16 |
| F | CONSTRUCTION | 4,456 | 150 | 947 | 78 | 378 | 27 |
| G | WHOLESALE AND RETAIL TRADE; REPAIR OF MOTOR VEHICLES, MOTORCYCLES AND PERSONAL AND HOUSEHOLD GOODS | 14,400 | 1764 | 1,041 | 569 | 340 | 102 |
| H | HOTELS AND RESTAURANTS | 2,811 | 177 | n/a | 53 | n/a | n/a |
| I | TRANSPORT, STORAGE AND COMMUNICATION | 2,564 | 574 | 773 | 150 | 368 | 50 |
| J | FINANCIAL INTERMEDIATION | n/a | 790 | 405 | n/a | n/a | n/a |
| K | REAL ESTATE, RENTING AND BUSINESS ACTIVITIES | 10,163 | 1112 | 1,386 | 332 | 634 | 45 |
| M | EDUCATION | 1,562 | n/a | n/a | n/a | n/a | n/a |
| N | HEALTH AND SOCIAL WORK | 1,519 | n/a | n/a | n/a | n/a | n/a |
| O | OTHER COMMUNITY, SOCIAL AND PERSONAL SERVICE ACTIVITIES | 3,457 | n/a | n/a | n/a | n/a | n/a |

**Notes:** Observations are reporting units. In terms of usable observations numbers are lower, for example:

- e-commerce has 7,318 observations, but 44 are problematic and 1 incomplete.
- ABI questions on e-commerce are problematic or incomplete for all except 34,645 of the 53,197observations, but still provide by far the largest evidence base.

# 3 Data Sources for Economic Analysis

*3.1 Annual Business Inquiry*

Included in the 2000 and subsequent ABI surveys for UK firms has been a question on use of electronic networks (internet or other networks) for placing or receiving orders. The format for these questions, which effectively use the OECD 'broad' definition of e-commerce is:

**Figure 3.1**

| **E-COMMERCE** | | |
|---|---|---|
| If you use the Internet, Electronic Data Interchange or any other electronic network to:- | | |
| Place orders for goods or services, please **enter '1'** in the box provided. If not, please **enter '2'** | | |
| Receive orders for goods or services, please **enter '1'** in the box provided. If not, please **enter '2'** | | |
| | | |

This data, for e-commerce use and all the normal Structural Business Statistics set of employment, gross and net output, and inputs (including purchased ICT services as a specified item) is available for a sample of over 7,000 reporting units in the manufacturing sector, and has delivered highly significant results. It has also been used for initial analysis of an even larger number of reporting units in the service sector, but looking simply at labour productivity because the services data-set does not yet have accompanying estimates of firm level capital stock as the manufacturing data does.

The UK ABI is available for analysis as a longitudinally linked dataset, for manufacturing back beyond the 1990s. Preliminary data for 2001 became available at the later stages of our work programme, and some results have been tested with this data, but most of the work is based on 2000 data and earlier.

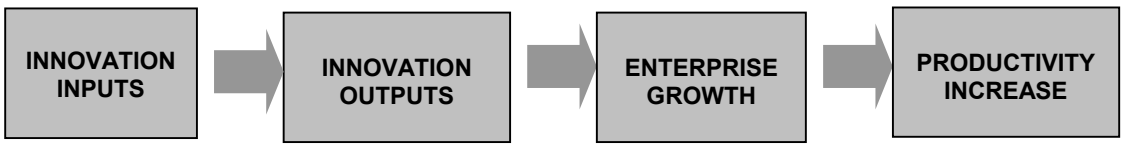
In addition, the ABI / ARD has associated with it estimates of fixed capital stock for all manufacturing reporting units, built up from reported capital purchases using a perpetual inventory model at firm level, plus reported operating inventory levels (materials, work in progress and finished stocks) for all units (both manufacturing and services) which we have used for an exploration of e-commerce and operating efficiency in retailing.

*3.2 Community Innovation Survey*

This survey is available for research in the UK for the years 1996 and 2000. Linking ABI output and productivity data to innovation surveys has been achieved, both for rounds. This has been used to test a number of relationships between inputs to innovation, innovation outputs (product and process), and productivity effects of innovation. Much of this work has been done in a parallel research programme in ONS, some of whose results are used in this report. ( see Innovations and Productivity Growth, Criscuolo and Haskel 2002, www.ceriba.org.uk).

Links for the first two relationships in the linear innovation chain:

**Figure 3.2**



have also been tested using CIS 2000 data as part of this project (see section 9), and the validity of the basic model supported within limits.

*3.3 Producer Price Inquiry*

The third major data-set used in linked work to date was not anticipated in our original project plans, but became of interest as a source to explain the key result relating e-commerce use to productivity in manufacturing. When it became clear that value added per employee is positively related to use of electronic networks for buying, and negatively related to electronic selling, this seemed strong prima facie evidence that at least part of the effect was as a result of price effects.

The data available to test this possibility is the ONS' producer price database, made up of monthly quotes for specified products from thousands of producers. Each one is linked back, in quality corrected format, to a base year of 1995 and the data is used to produce sector price indices (representing prices for industrial output) which are used to deflate the output measure of GDP. Because the database carries both the business register number of the contributing firm, and the detailed sector identifier for the product it refers to, it is possible to re-cast the data into indices which show separately the results for firms that sell using e-commerce, and the results for those that do not.

Unlike the other data-sets discussed above (ABI, CIS, e-commerce) the PPI data-sets are not available for analysis by external researchers, even under strict confidentiality conditions. This is because of the exceptional sensitivity surrounding price quote data.

*3.4 e-Commerce survey*

Linking the e-commerce survey to structural business statistics has been achieved, through the UK business register. It has proved possible, mainly for larger enterprises, to achieve matching of e-commerce responses to ABI performance data on the same respondents for :

- gross value added per employee
- extra-UK activity
- capital investment, and ICT purchases, as well as other inputs at enterprise level.

However, the number of enterprises for which linking between the e-commerce survey and ABI has proved possible using the 2000 survey is 1928, of which only 707 are in manufacturing. This sample has been used for trial regression analysis of total factor productivity, without statistically significant results. For this reason, subsequent analysis on TFP (reported in section 6) has been based on qualitative questions from the ABI (described in 3.1 above) on use of electronic networks for placing and receiving orders.

The overlaps between ABI, e-commerce and CIS data-sets are too small to permit statistically robust conclusions on the effect of e-commerce (as measured in the e-commerce survey) to be derived. However, the CIS data-set itself contains questions on e-commerce use, and these have been used to test possible:

- influence of electronic networks on innovation inputs
- effects of electronic networks on exploiting innovation outputs.

**Figure 3.3**

Relevant data from the three output / activity survey sources can be summarised as follows:

| | **ABI / ARD** | **CIS** | **E-commerce** |
|---|---|---|---|
| Turnover | , | , | , |
| Purchases | , | . | . |
| Employment | , | , | . |
| Value Added | , | . | . |
| IT expenditure | , | . | . |
| Advertising expenditure | , | . | . |
| ICT usage | . | . | , |
| Date of ICT adoption | . | . | , |
| Benefits of technology | . | , | , |
| E-commerce Activity (yes/no) | , (broad defn.) | , (narrow defn.) | , (both defns.) |
| Amount of e-commerce (% of sales) | . | . | , |
| Split sales and purchases | , | . | , |
| Innovation | . | , | . |
| Collaboration | . | , | . |
| Industry | , | , | , |
| Exports | , | , | . |
| Skills | . | , | . |

The UK e-commerce survey for 2001 also contained, for 2001, questions on the use of e-business processes other than buying and selling. This type of question, as we found from the work reported in section 6, has value. Although we have demonstrated that linking of this data to ABI data is possible, the number of observations is as yet too small for statistically reliable results

### *3.5 Capital Investment Surveys*

One additional data-set (or rather pair of data-sets) was considered for use in this work, but was found to be impractical in the time available. In addition to partial investment data collected with the ABI, ONS conducts two more detailed capital investment surveys, one quarterly the other annual. In principle it will be possible for these to be used to build a firm level data-set on ICT capital, covering both hardware and software.

The benefit of having an ICT capital stock measure available at firm level is that it would be possible to distinguish in econometric analysis between capital invested in ICT infrastructure (from investment surveys), ongoing purchases of ICT services (from ABI) and measures of ICT usage (from the e-commerce and other surveys) which specifically measure behaviour and organisation. This would enable us to use UK data to investigate conclusions from other studies which have found the impact of ICT investment to be conditional on organisational and behaviour factors.

However, the surveys have only been in operation since 1998 and 2000, and there is today insufficient history to create a capital stock measure at firm level using the perpetual inventory

methodology - even given the relatively short life for ICT assets. Analysis using firm level ICT capital stocks will be tackled in a subsequent project.

# 4 Summary of statistical results

The main statistical results from analysis contained in this report are as follows:

## *4.1 e-Commerce adoption*

- Multiple technology platforms for ICT support the firms with higher levels of e-commerce activity
- Typical lag between firms adopting connected technologies and moving to e-commerce is of the order of two years
- Non internet channels for e-commerce still dominate overall e-commerce volumes, except for smaller firms, for whom the internet is a point of entry
- The proportion of 'marginal' e-sellers, for whom e-commerce is 1% or less of sales, has fallen since 2000, but is still not insignificant
- Early adopters of e-commerce tend to have a more focused view of specific business benefits; later adopters tend to emphasise market access
- Levels of entry, exit and experimentation in electronic markets, underlying the growth of adoption, are high

## *4.2 Productivity in manufacturing*

- Linked data using e-commerce surveys is not yet available in sufficient sample sizes to permit successful statistical analysis of productivity effects
- Linking productivity performance to qualitative questions on the structural business survey has established statistically significant productivity relationships across manufacturing firms
- The most significant, and largest, productivity gain associated with e-commerce use is associated with electronic procurement
- Electronic selling is associated with lower productivity, as measured in terms of value added
- A major part of this effect appears to be due to price effects caused by e-commerce, but there is also evidence for an overall efficiency gain effect
- Regression analysis shows that these results are not affected by selection bias, and that they apply to small as well as large firms
- While these conclusions hold good for the majority of manufacturing sectors, there are some (where services or information products are important) in which the negative effects of e-selling are not present

## *4.3 Price effects*

- It has proved possible to link e-commerce indicators for firms to their responses to monthly price inquiries, and through this to test the price effects which appear to be present in the manufacturing productivity data
- In the majority of a selected set of sectors tested, the producer price data supports the conclusion that e-commerce use for selling tends to depress prices, relative to firms in the same sector (or producing the same products) which do not use e-commerce for selling
- There are, however, a number of sectors where this effect is not present, and a few where it is reversed; some of these may be explained by industry characteristics

- Experts in e-commerce systems have suggested to us that industry structure plays a role in determining how e-commerce affects the balance of advantage between buyers and sellers

### *4.4 Service sector; retailing and stocks*

- There are sectors in services (e.g. retailing) where e-selling seems to generate labour productivity gains - measured in terms of both value added per employee and gross output per employee
- Our analysis of operational effects of e-commerce use has focused on retailing because this is a relatively homogeneous sector in terms of technology and business processes; elsewhere the data is too heterogeneous to permit analysis
- E-procurement produces limited benefits for both stock turn and labour productivity in certain areas of retailing; size and sub-sector influence where the advantage lies
- E-selling (in the absence of e-procurement) usually demands higher stock levels relative to sales turnover, as well as generating higher productivity
- Through integration (e-buying and selling) is associated with stock turn advantages, and with higher productivity, in retail sectors other than food shops.

### *4.5 R&D and innovation*

- Parallel research conducted in ONS using the Community Innovation Survey 1996 and 2000 has produced regression evidence that links innovation output (presence and % of innovative sales in firm output) to R&D spending and to collaboration in innovation inputs
- The parallel work has also produced regression evidence linking both product and process innovation to productivity gain, measured in terms of TFP
- Our analysis, based on CIS 2000, has shown firm level links between
  - relative innovation spending within sector and innovation output (% products new to firm)
  - R&D and IC spending within sector and innovation output (% products new to firm)
  - relative innovation output, and relative firm growth
- E-commerce use does not appear to be directly related to either of these relationships
- However, e-commerce use, measured by linking ABI and CIS data on electronic network use, is positively related to
  - the probability that firms collaborate in innovative activities
  - the number of collaborative relationships they are likely to have
- It appears that the role of electronic networks in facilitating innovation is easier to detect in the field of collaborative communication than in direct commercialisation of innovation.

# 5 e-Commerce adoption evidence

## *5.1 Background*

ONS has so far published two e-commerce surveys, the initial survey for 2000, based very closely on the Eurostat model, and the second for 2001, published in stages during August - November 2002 (Prestwood, 2002). The 2000 survey contained questions on date of adoption of technologies, and on benefits and barriers related to e-commerce adoption. Data from the 2000 survey is therefore most useful in detailed analysis of adoption behaviour by business, and much of the work reported in this section is based on it. It shows that patterns of e-commerce use vary widely across UK industry.

Comparisons of 2000 to 2001 e-commerce data have been made as part of the adoption analysis. They show a high level of experimentation and change under way, with firms declaring that they enter and leave the e-commerce arena in large numbers. This will be important to recognise when we come to look at impact on performance.

Statistical work in other OECD countries, and case studies conducted for the DTI and DG Enterprise, have demonstrated common patterns of e-commerce adoption, and shared factors in the ability of businesses to capitalise on ICT benefits. Input from these studies has helped focus our analytical approach on three strands:

- tabulation of the 2000 / 2001 e-commerce surveys, to understand the relationships between technology use and adoption of electronic transactions
- modelling enterprise productivity levels and changes, taking into account the use of computer networks and electronic transactions, an extension of work already carried out in the US Bureau of Census (Atrostic and Nguyen, 2002).
- analysis of R&D, innovation and output growth, to test whether use of electronic networks can improve the effectiveness of investment in innovation

This section focuses on the comparisons we have been able to make covering the infrastructure required to support e-commerce, the rate and distribution of adoption, sector differences, perceived business benefits, leads and lags, and the year on year changes which suggest high rates of entry and exit.

## *5.2 Technology infrastructure in firms*

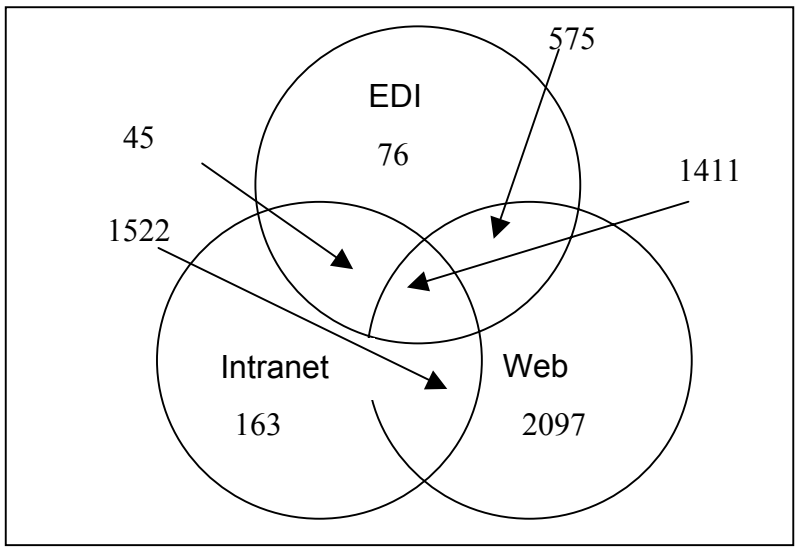
The ONS e-commerce survey launched in 2000, based on Eurostat's model contains questions on dates by which firms had made investment in specific forms of communications technology. It gathers data on the adoption patterns and use of Information and Communication Technologies (ICT) by UK enterprises. The 2000 survey showed that the majority of UK firms had invested in some form of 'connected' technology, and that many were using more than one technology.

Figure 5.1 shows the pattern of technology in use for connected firms, and the relationships between older technologies, such as intranet (internal networks within firms) and electronic data interchange (EDI, which links firms over closed transaction networks) and the more recent web technology.

Only web access shows up as a 'standalone' technology in use by a significant number of firms on its own, although half of firms accessing the web were also using intranet or EDI. 20% of survey respondents, 1411 in total were using all three - web access, intranet and closed links

with business partners via EDI. A similar number, 1385 or 19% of respondents, had no connection at all.

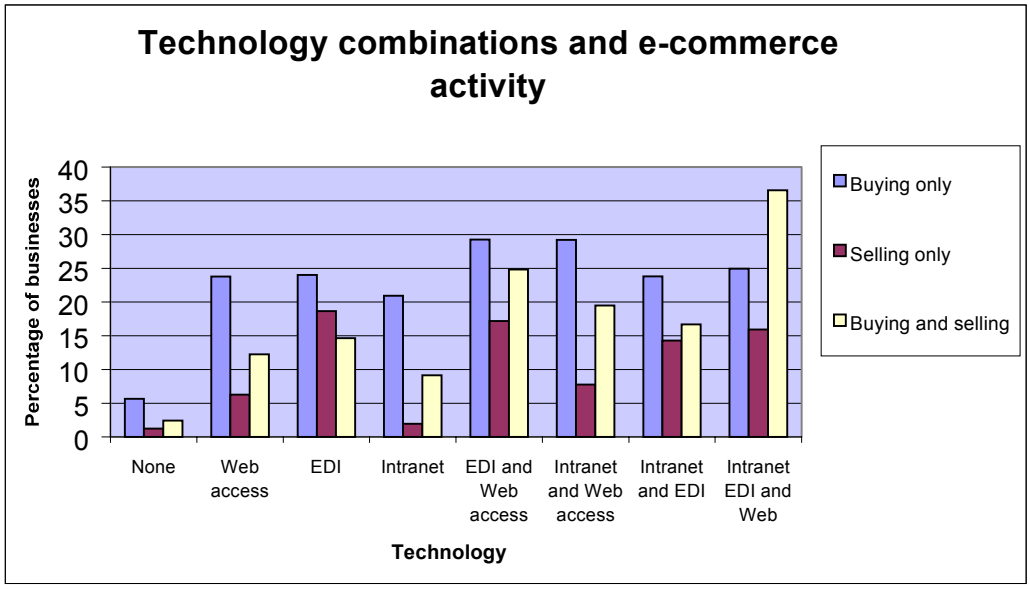
**Figure 5.1 Distribution of 'connected' technologies in firms**




Source; e-Commerce Survey 2000

Figure 5.2 shows that use of multiple 'connected' technologies is positively related to penetration of use of e-commerce. There are a small number of reporting businesses without any of these technologies who engage in e-commerce via third party web sites, but for the rest, more than one channel for e-business often means a higher proportion able to undertake electronic sales. In addition, ownership of an intranet, connecting internal processes within a firm, increases the likelihood that it will be able to buy and sell electronically.

**Figure 5. 2**

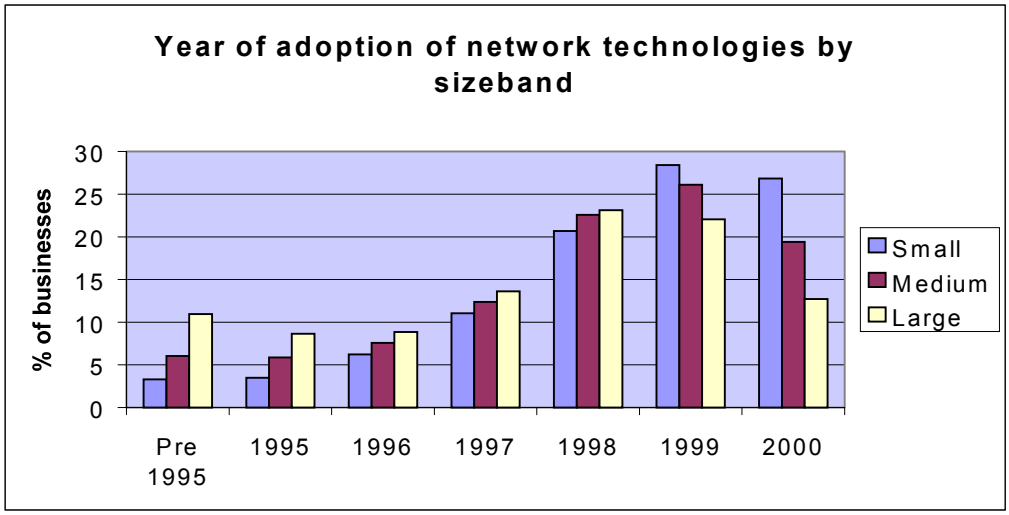



Source; e-Commerce Survey 2000

*5.3 Rate and distribution of adoption*

EDI predates the internet by 20 years, but its role a vehicle for e-commerce is still important. Almost all large firms in the 2000 e-commerce survey used some form of connected technology, (often EDI) and 40% of large firms were already doing so by 1997 (Fig 5.3). The internet boom of 1999/2000 drew in many more firms, but more of the 'late joiners' were small and medium sized enterprises, under 250 employees.

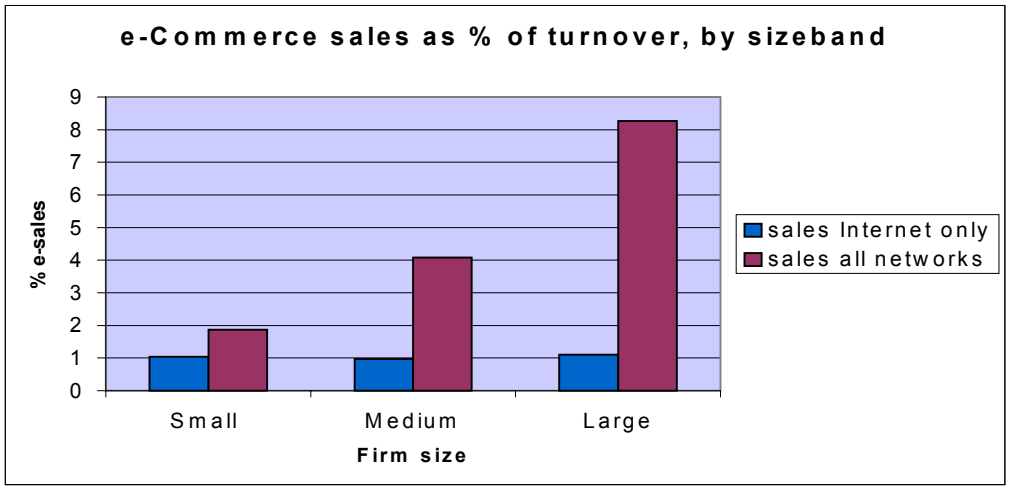
**Figure 5.3**




Source; e-Commerce Survey 2000

Because many larger firms that were ICT enabled since the mid 1990s used electronic exchange of orders or of information over closed systems, EDI dominates measures of value of e-commerce in both 2000 and 2001. Figure 5.4 shows, for the year 2000, business done over the internet and via 'all electronic networks', of which EDI is the largest element. In small firms, the proportion of business sold over the internet is half of all electronic sales, which implies that EDI and internet sales are roughly comparable. For large firms internet sales are only around 12% of total network sales, with EDI and other systems accounting for the rest. This suggests the internet is a point of entry to electronic trading for small firms, giving them access to e-business activity.

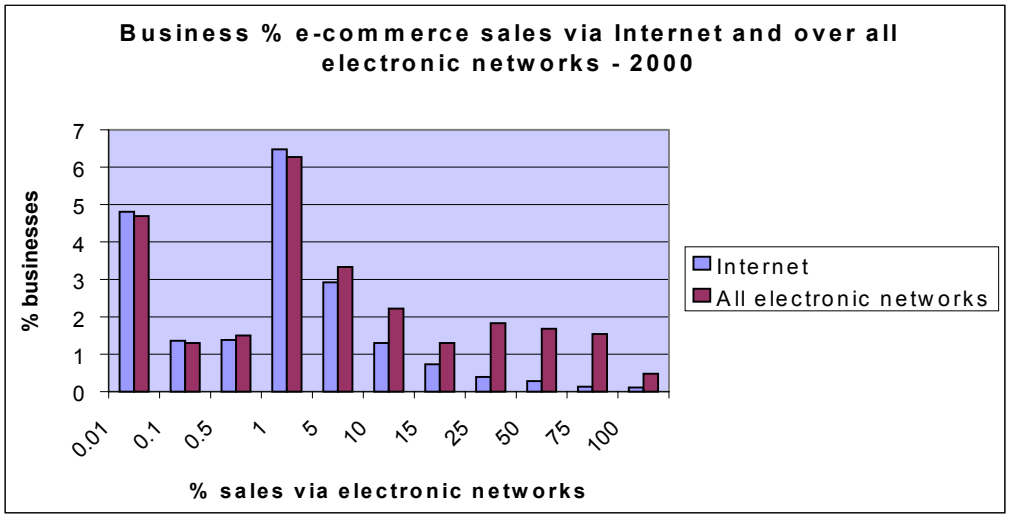
**Figure 5.4**




Source; e-Commerce Survey 2000

Analysis of the pattern of electronic transactions as a percentage of enterprise turnover (Figure 5.5) shows a similar effect. The majority of businesses for which e-commerce constitutes over 10% of sales value, use non-internet networks.

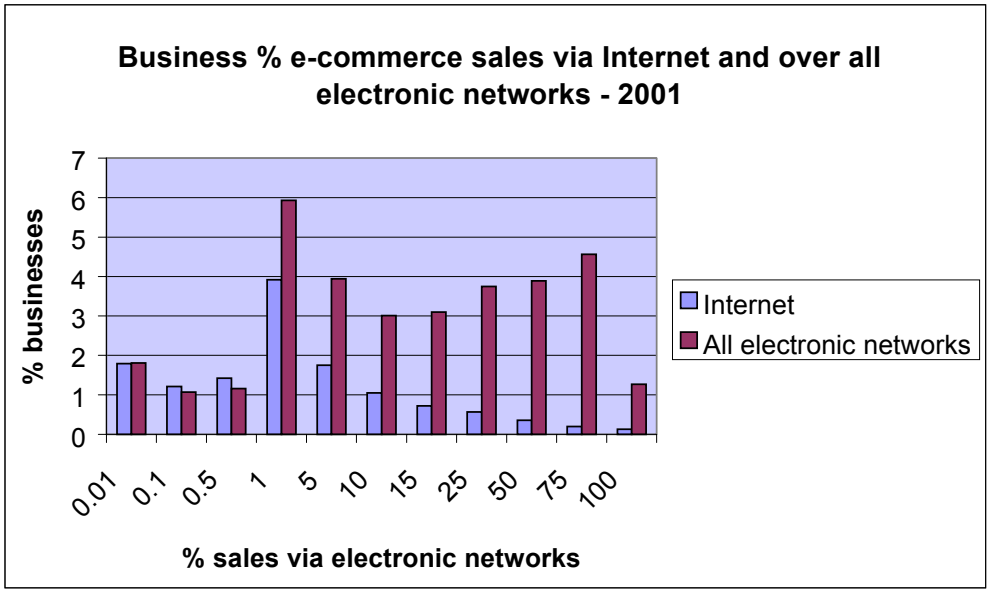
**Figure 5.5**




Source; e-Commerce Survey 2000

It is clear from the analysis in Figure 5.5 that a high proportion of businesses undertaking e-commerce sales in 2000 were very 'marginal e-traders'. For well over half the businesses undertaking electronic sales, this activity accounted for 1% or less of their turnover. UK survey data for 2001 shows that this pattern has changed significantly. By 2001 there is a significantly higher proportion of e-traders in the 'over 1% of sales' bands, and a definite reduction in the proportion of very marginal users. A large part of the increase among the more intensive e-commerce businesses appears to be among users of non-internet technologies. These year to year comparisons need to be read with some caveats, because of changes in the survey format and coverage, and because the survey operation itself is still developing.

**Figure 5.6**




Source; e-Commerce Survey 2001

*5.4 Sector balance of e-purchasers and e-sellers*

The sector pattern of e-commerce sales has been published in value terms in ONS releases (Prestwood 2002). It shows significant differences across sectors for values of electronic sales as a percentage of total sales, by broad SIC category. An alternative approach is to look at selling and buying behaviour, focusing on the proportion of businesses for whom e-commerce represents more than 1% of sales, and the proportion for whom it represents more that 1% of purchases. This gives a pointer to how e-commerce is used by sector. Table 5.1 shows that:

- the food, drink and tobacco sector has by far the greatest proportion of 'non-marginal' e-traders, over 40%. Sales from this sector via EDI to supermarkets and wholesalers have been an established business practice for several years.
- the wholesale / retail sector has among the highest proportion of electronic purchasers (22%), along with financial services (23%), business services (20%) and electrical / optical machinery (21%)

The pattern in Table 5.1 seems to suggest that e-commerce involves a significant proportion of firms in sectors where the number of suppliers and / or buyers is low. This model of e-commerce is likely to be a closed system of EDI. Where customers are more fragmented and the market structure suited to the internet, penetration appears slower.

**Table 5.1 e-Purchasers vs. e-Sellers**

| **Selected industry sectors** | % firms with more than 1% e-purchases | % firms with more than 1% e-sales |
|---|---|---|
| **Higher user sectors:** | | |
| Food / drink / tobacco | 12 | 45 |
| *Paper etc* | 16 | 12 |
| Chemicals | 17 | 19 |
| *Rubber / plastic* | 19 | 14 |
| *Equipment / machinery* | 18 | 10 |
| *Electrical / optical machinery* | 21 | 12 |
| *Transport equipment* | 16 | 12 |
| *Utilities* | 21 | 10 |
| *Wholesale / retail* | 22 | 14 |
| *Hotels / catering* | 13 | 11 |
| *Real estate / business services* | 20 | 6 |
| *Transport* | 18 | 12 |
| *Financial services* | 23 | 17 |
| **Lower user sectors:** | | |
| Textiles | 7 | 11 |
| Leather | 8 | 7 |
| Non-metallic products | 6 | 8 |
| Metal products (11%) | 10 | 11 |
| *Manufacturing nes.(7%)* | 8 | 6 |

Source; e-Commerce Survey 2000

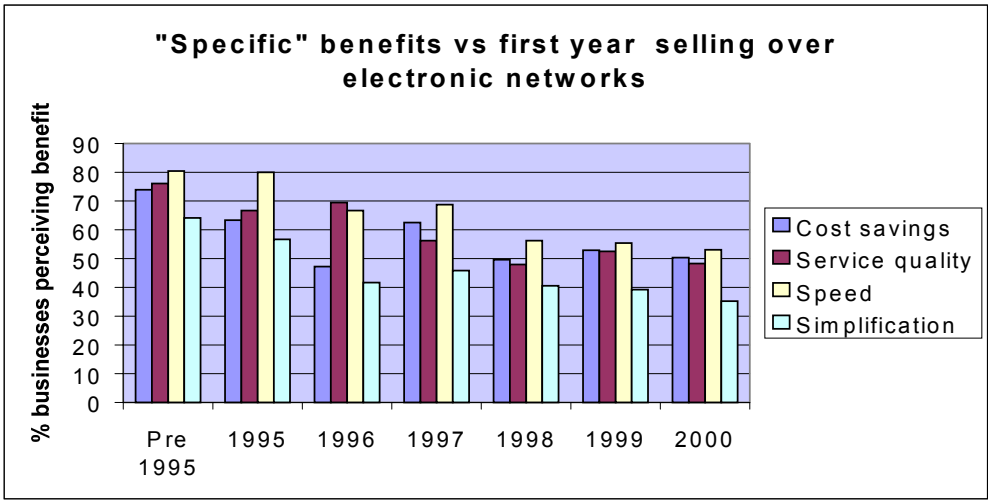
Sectors shown in italics have fewer >1% e-sellers than >1% e-purchasers

This 'buyer / seller' analysis confirms that for the majority of sectors, the proportion of 'non-marginal e-purchasers' is greater than that of 'non-marginal e-sellers'.

*5.5 Perceived business benefits of e-commerce*

Responses to survey questions on the benefits associated with e-commerce use show that business objectives for electronic trading have changed over time. Firms which began using computer networks or the internet prior to 1997 are more likely to have reported their reasons for doing so in terms of very specific business benefits (Fig. 5.7). They report benefits including cost reduction for the firm, service quality improvement for customers, increased speed of operation and simplification of business processes. These are benefits which usually require electronic processes to be 'engineered in' to firms, affecting workflows, or the way firms interact with customers.

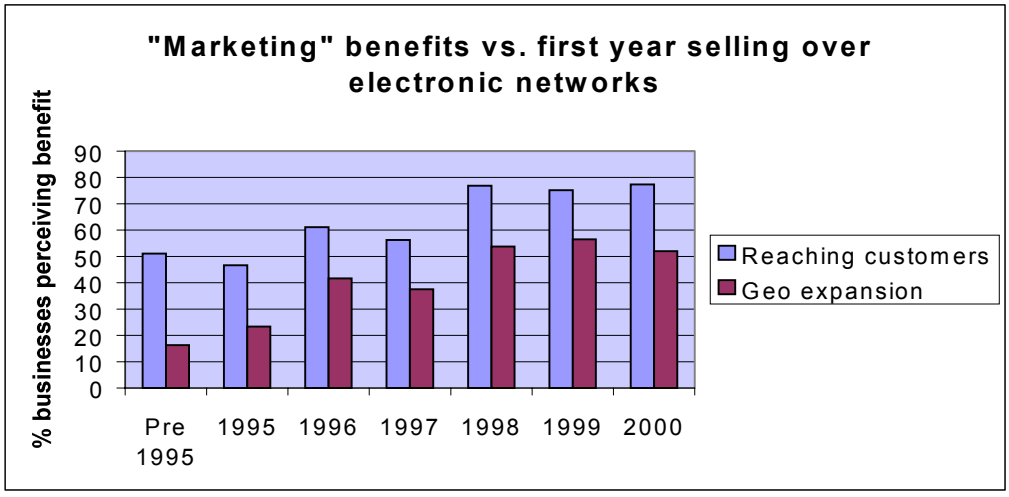
**Figure 5.7**




Source; e-Commerce Survey 2000

Figure 5.8 shows, by way of contrast, that benefits reported by later adopters seem more related to marketing goals. The majority of these report their main objectives as geographic expansion or reaching customers. Often these objectives are less specific, and require less investment in business processes than cost savings, service quality, speed or process simplification. Further analysis may show whether businesses with primarily marketing priorities are among the 'marginal' businesses in Figure 5.5 above.

**Figure 5.8**

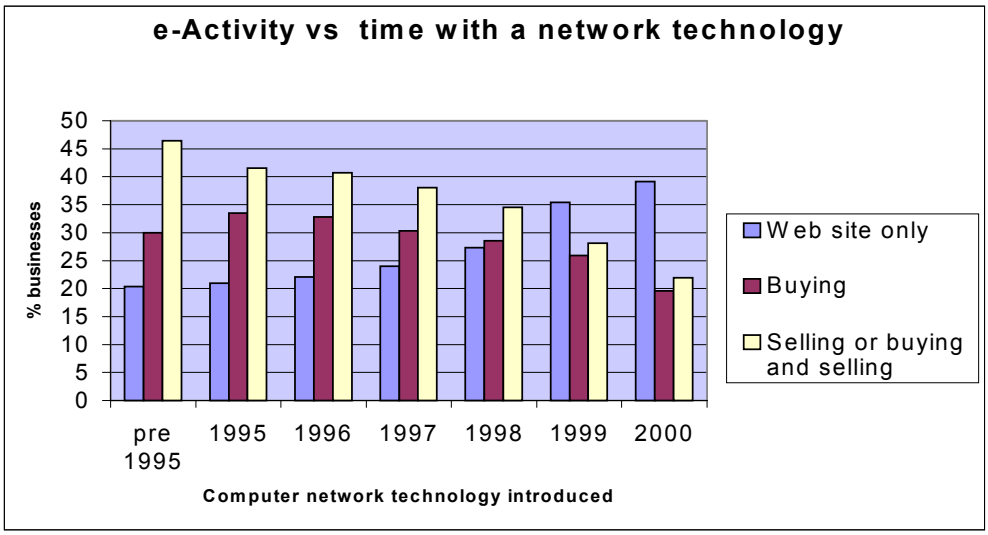



Source; e-Commerce Survey 2000

## *5.6 Leads and lags*

Most important for identifying the impact of ICT and e-commerce use for business performance is an understanding of lags involved in the adoption process. From survey responses it is possible to identify how long firms are likely to take to move from initial investment in 'connected' ICT to trading on-line, either as a buyer or as a seller. For example those investing in the technology pre 1995 had a 46% probability by 2000 of selling via e-commerce and possibly buying as well. Those investing in 2000 only had a 21% probability of trading - and were nearly twice as likely to have only a marketing web site. The sharpest increase in probability of trading takes place in the first two years of adoption - which suggests a learning period for many firms to move from technology to business operations.

**Figure 5.9**




Source; e-Commerce Survey 2000

This result may be related to the responses on benefits to e-trading reported in Figure 5.7 above. Time taken to embed electronic processes to enable effective trading and secure benefits is probably measured in years rather than months. We will need to recognise this in looking for 'impact' benefits of technology.

## *5.7 Entry and exit*

While the analysis shown in Figures 5.5 and 5.6 above allow us to compare broad patterns of adoption and e-commerce usage for 2000 and 2001, using the whole sample for each year, we are also able for the first time to follow the progress of individual respondents. From this we can derive an initial assessment of how stable established e-commerce users might be, and the rate of new take-up.

2716 reporting units appear in both the 2000 and 2001 survey. 1302 of these (48%) made no e-sales in either year, as broadly defined, either over he internet or using other electronic networks. Of 858 firms which gave a non-zero estimate of electronic sales in 2000, 189 (22%) gave zero for 2001, and 166 (19%) reported that their share of e-commerce had fallen. For over 40% of 2000 users e-commerce activity had declined.

By 2001 there were, of the total linked set, 1225 units which gave a non-zero response for broadly defined e-commerce activity, up 42% on the year before. Of these 556 were reporting positive values for the first time, which means that of reported e-commerce users in 2001 45% had reported use for less than a year.

**Table 5.2 2000/2001 responses linked; % sales over all networks**

| % sales via networks in 2000 | Eliminated by 2001 | Reduced by 2001 | No change by 2001 | Increased by 2001 | Total |
|---|---|---|---|---|---|
| 0 | 0 | 0 | 1302 | 556 | 1858 |
| > 0 and<5% | 123 | 40 | 51 | 219 | 433 |
| 5% to <50% | 58 | 74 | 31 | 113 | 276 |
| 50% to 100% | 8 | 52 | 26 | 63 | 149 |
| Total | 189 | 166 | 1410 | 951 | 2716 |

Source: e-commerce surveys 2000/2001

These figures may not be representative of the whole population over which the surveys were conducted, and it is possible that some definitional differences affect comparisons from one year to the next. However, the data does show very high levels of entry and exit from e-markets, and the relatively low proportion of firms which appear to be consistent users of electronic networks for selling in 2000/2001.

Over this period there was a high rate of business failure among dot.com businesses, many of which did not exist to be captured in a 2001 survey. Therefore this longitudinally linked analysis probably understates the amount of turbulence - especially the numbers of businesses leaving electronic markets. Similar results have been obtained from separate longitudinal linking of responses for e-commerce via internet, EDI and for intranet use. In each area measured, and across the size range of firms, the overall growth in activity hides significant entry and exit.

The data shows a dynamic pattern, with experimentation and exit still widespread. This will affect the ease with which we can identify costs and benefits of e-commerce use.

# 6 Productivity in manufacturing

## *6.1 Background to selection of approach*

Micro-data work to investigate the effects of ICT investment and use is now being undertaken in a range of countries, drawing on data-sets from official and private sources. Most of these investigate the effects on firm productivity which can be attributed to ICT inputs, either through quantified measures of ICT investment, or through availability or use of ICT systems. Evidence from a range of sources has been brought together by OECD through a collaborative group which has contributed to the report 'ICT, seizing the benefits', which has informed the study reported here.

The main approaches to this work include:

- inclusion of ICT capital stock at firm level as a separately identified capital input to labour productivity or TFP measurement (Brynjolfsson & Hitt, Hempell)
- including ICT capital alongside other measures of ICT use, such as internet use or number of employees using ICT (Maliranta & Rouvinen)
- including ICT capital stock together with measures on innovation and / or organisation change (van Leeuwen & van der Weil, Brynjolfsson & Hitt)
- including measures of computer network use as a determinant of labour productivity or TFP in a standard production function equation (Atrostic and Nguyen).

In our linked data-sets for the UK, we do not yet have enough basic survey data to construct individual firm level ICT capital stock using perpetual inventory methods. This gap in data should be possible to remedy within the next year as the base of detailed capital expenditure surveys reaches a sufficiently long back series. But for our immediate work it is not available. The methodology adopted for initial analysis of ICT productivity effects is therefore based on the Atrostic and Nguyen approach, based on US Bureau of Census data, developed where possible to take account of additional dimensions in UK sources.

Atrostic and Nguyen show, using the US 1999 manufacturing census combined with a large scale computer network use supplementary survey, that there is a significant positive effect on productivity associated with the use of computer networks, after allowing for management and other effects. This conclusion is derived through a standard production function regression which takes into account:

- labour and capital inputs
- size of reporting unit, and whether it is part of a multi-plant firm
- skills measured as occupation type
- industry dummies
- the use of computer networks by the unit for a range of business processes

The US Computer Network Use Survey (CNUS) was completed by more than 38,000 firms. It consists mainly of qualitative (tick box) measures of the extent to which computer networks were used for buying and selling, logistics, operations, and other steps in the business' value chain. Of the firms reporting use of computer networks, only half were using them to buy or sell, so network use for 'e-business' as opposed to 'e-commerce' purposes is an important part of the overall picture.

From this data-set, Atrostic and Nguyen test whether the use of computer networks in 1999 had the effect of shifting the production function in such a way as to increase productivity. They conclude that it adds around 5% to output per employee, and that this result is robust to different model specifications. The results are also tested for selection bias. This successful use of qualitative ICT data on a large sample appeared to be the best model given the UK data available.

The closest UK source to this US data is provided by the qualitative questions added to the UK structural business survey (ABI) from 2000 onwards, shown earlier in section 3. These ask firm to firms to indicate - yes or no - whether they use electronic networks to place orders for goods and services, or to receive orders. This is the OECD 'broad definition' of e-commerce use.

There is interest in looking at the effect of e-commerce as a means of procurement or of supply chain management separate from its other applications, supported by case evidence. Adoption of electronic procurement systems by firms has been claimed to improve efficiency in several ways, by cutting internal administration costs and speeding up purchasing processes, by improving price transparency, by reducing search costs and therefore the efficient operation of choice in markets. A well documented example of case evidence was provided by Siemens to the DG Enterprise e-business w@tch workshop in November 2002, emphasising that procurement savings to the company came from both internal and external sources.

The ABI data, separating buying and selling via electronic networks makes it possible to analyse the distinct impacts for a very large sample.

### *6.2 Regression analysis*

The ABI data provides the nearest equivalent, in type of question, and in ability to link to a large sample of performance data, to the US approach. It does not cover the 'e-business' application of computer networks as the US data does, but it does permit us to separate the e-commerce applications between buying and selling.

A TFP analysis using UK ABI data is restricted to the manufacturing sector, because firm level capital stock data is not yet available for services. For manufacturing the ABI for 2000 provides a total possible research data-set of over 11,000 reporting units (see Table 2.1 in section 2), reduced to around 7,000 after removing observations where the e-commerce response was invalid or missing.

The framework for regression analysis is Cob-Douglas production function of the form:

$$Q = AK^{\alpha}L^{\beta}M^{\gamma}$$

where K, L and M are capital, labour and materials inputs (all available from the ABI) and A is a technology change term which shifts the production function as a function of the use of computer / electronic networks for buying or selling, of the form:

$$A = \exp(\delta_0 + \delta_1 CNETuse)$$

and where *CNETuse* has the value 1 if e reporting unit uses a network for buying or selling, and zero if it does not. The equation on which regression is based is therefore:

$$\ln\left(\frac{Q}{L}\right) = \delta_0 + \delta_1 CNETuse + \alpha \ln\left(\frac{K}{L}\right) + \gamma \ln\left(\frac{M}{L}\right) - (\alpha + \beta + \gamma - 1)\ln L$$

The *CNETuse* term in the analysis is split into a number of dimensions for different specifications of the model, to show separately the effects for:

- firms using computer networks for selling
- firms using computer networks for buying
- firms using networks for either buying or selling
- firms using networks for both buying and selling

The reasons for doing this are to investigate during the analysis how possible 'market effects' due to use of computer networks can be separated from internal efficiency effects, and also to test a hypothesis that firms using networks to both buy and sell might be better integrated and so more productive.

In addition to these factors, the analysis of 2000 data also takes account of:

- reporting unit size, as represented by number of employees
- industry sector and location
- ownership structure, (multinational status which parallel work has shown has major influence)
- age of plant

Results of this analysis for 2000 have been developed using gross (sales) and net (value added) measures of total factor productivity, and for value added per employee. All show statistically significant effects. Consistent positive correlation exists in all three specifications, between use of computer networks for buying and:

- value added per employee
- total factor productivity based on gross output, and
- total factor productivity based on value added

Results in this format (shown in full in Table 6.1) are the most reliable, because they include multinational ownership as a productivity determining factor, which is highly significant in its own right. It is also in this specification that the regression has been tested for selection bias (using a two stage probit estimate, and employing ICT expenditure by the firm in prior years as an instrumental variable). The significance of the results is comparable to those achieved by Atrostic and Nguyen

As we do not yet have multinational markers for 2001, the 2001 ABI data cannot be analysed in precisely the same way. However it has been possible to test the regression on 2000 and 2001 data excluding these terms, and show that the productivity impacts for *CNETuse* terms is similar and significant in both years . Results for both years together are shown in Table 6.2.

### *6.3 Interpreting the regression results*

The regression results show, like the Atrostic and Nguyen analysis, an overall positive effect on firm productivity - on all the three measures listed above - associated with use of computer networks for trading. However, it is clear from comparing the gross output result with the value added results that pricing effects play large part in this result. In both Table 6.1 and 6.2, the gross output results show a 2.5% gain in output associated with e-procurement. However, the value added results show gains associated with e-procurement between 7.7% and 8.9%, and a loss of value added associated with e-selling of between 5 and 6%. The most likely explanation

for the gain to buyers and the loss to sellers appears to be due to pricing effects, with internal efficiency gains accounting for the difference.

The relationships between the coefficients for the gross output and value added equations would be consistent with the interpretation that these results include the effects of lower prices in 'electronic markets'. Three results support this:

- value added / gross output ratios across the manufacturing sectors are typically below 50%, so price reductions would produce, pro-rata, much greater coefficients for value added than for gross output.
- the effects of 'only e-buying' show up as weak and insignificant in the gross output equations, as might be expected if the main effect was on input prices.
- by contrast the effects of 'only e-buying' show up as strongest and most significant in the value added equations, which would be affected by differential pricing.

In effect, what is being measured in these equations is partly a 'measurement error due to price' in the specification of the production function, because the normal assumption that prices are similarly behaved within industries is not being met. Section 7 will explore direct evidence on this question, from linking UK pricing data to e-commerce use by producing firms.

The hypothesis that firms which both buy and sell are likely to be more 'integrated' in terms of their network use, and therefore more efficient, is not supported by the results. Units which both buy and sell, appear with a significant additional productivity effect in only one of the six forms of the model in tables 6.1 and 6.2 - the one for labour productivity omitting the multinational markers. It is at least possible that multinationals would be well represented among the firm types which would buy and sell electronically, if only to manage their internal transactions within the firm.

Another hypothesis advanced on the basis of case evidence, and the results reported so far, is that the 'price effect' which appears to benefit firms through e-procurement is partly due to large firms using electronic markets to strengthen their position at the expense of smaller ones. For example, if a large multinational firm is able to construct a procurement system which enables it to put all its purchasing requirement out to international tender, and buy in a global market, while its smaller suppliers tend to be local, and to be price takers unable to access wider markets, then smaller firms could be disadvantaged. Alternatively, smaller buyers could find it difficult to buy electronically in international markets, and therefore unable to secure gains available to larger firms.

To test this possibility, the productivity analysis for 2000 and 2001 has been split, in Tables 6.3 and 6.4, between:

- reporting units which are smaller than the median size for their two digit sector, and so are likely to smaller firms with low market share (Table 6.3)
- reporting units which are larger than or equal to the median firm size in their two digit sector, which is likely to include market leaders (Table 6.4)

The results indicate that the productivity effects associated with e-buying and with e-selling are almost equally strong in large and small firms. Both show value added productivity loss

associated with e-selling, and the coefficients are up to twice as large for large firms as for small. Both groups of firms show value added productivity gains associated with e-procurement, with coefficients for the large firms only marginally bigger than for the small.

Comparing our results with Atrostic and Nguyen suggests that they are at least consistent. However, it seems possible that both approaches may understate productivity impacts of ICT at firm level:

- our analysis because it takes no account of e-business processes which are unrelated to buying or selling but are focused on other types of internal and external data management, which Atrostic and Nguyen found to be an important part of overall network use; in our data firms using networks in this way are categorised as 'non users'.

- Atrostic and Nguyen because their data does not distinguish transaction related e-commerce between buying and selling, and the analysis may therefore be unable to separate out the partly offsetting effects on both ides of transactions.

In order to overcome these analytical difficulties, the 'ideal' data-set for analysing computer network use effects would be long enough to allow time series analysis (which will take time, given that most EU countries only started collecting data in 2000), and would include:

- distinction between network use for buying and selling

- records of network use for other purposes (like the latest model Eurostat survey)

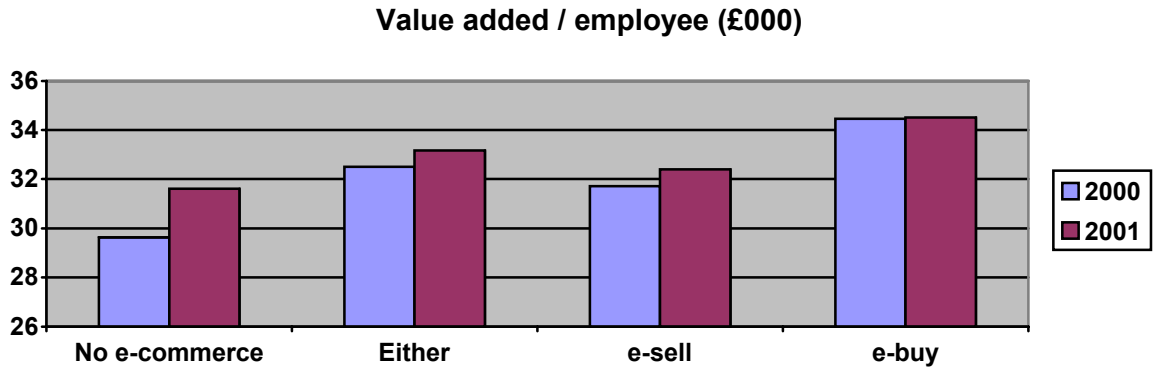
- access to price indices for individual firms, to enable us to show productivity in 'real' terms at firm level, and investigate output changes over time without having to assume that price indices apply uniformly across sectors.

UK e-commerce surveys from 2001 onwards contain data on e-business processes, but only linked to transactions. The Atrostic and Nguyen work suggests that we should consider widening the definition of e-business processes, and use an approach closer to the Bureau of Census CNUS. An initial analysis to test sensitivity of firm level price data to e-commerce use is considered in section 7.

### *6.4 Interpreting the data*

The effects shown in the regression results above are also evident in descriptive statistics. The data for 2000 and 2001 in Table 6.5, and in Figure 6.1 below shows that, for value added productivity measures, the best performing firms are those which use e-commerce for purchasing only.

**Figure 6.1**




Source; ABI surveys 2000/2001

A detailed breakdown of 2000 data by main manufacturing sector is shown in Table 6.6, and in Fig 6.2. three sectors are omitted from this analysis to avoid data disclosure issues, but the overall patter is strikingly supportive of the conclusions reached in the overall analysis. In the majority of sectors, firms with the highest value added per employee are those which use e-commerce for procurement. The raw data shows that - more often than not - firms which use e-commerce for selling are ahead in terms of value added of those firms who do not use electronic networks, but this is likely to be due to other factors, which were controlled for in the regression analysis (scale, organisation, capital stock).

Two sectors stand out in this industry analysis, where there are a large number of observations, and where e-selling firms come out ahead of those using e-commerce for procurement. These are:

- sector 22, publishing and media, where the sector has shown significant growth, and where the sales content of many firms includes information and services in addition to physical products and commodities
- sector 30, office equipment and computers, which shares these characteristics.

Both these sectors are the ones which have been most revolutionised by the 'information economy', sector 30 as a supplier and sector 22 as a consumer of ICT. It is at least possible that firms in these sectors have moved further to change business processes and methods of working to match the new technology, and may therefore be able to achieve gains from e-selling. In both, some firms have used electronic networks to 'leapfrog' the value chain to their eventual customers, cutting out intermediaries and appropriating part of their value added.

**Table 6.1**

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|---|
| MNE included | LP | | | TFP | | | | | |
| 2000 | Dependent variable: value added | | | Dependent variable: gross output | | | Dependent variable: value added | | |
| buy_or_sell | 0.006 | | | 0.002 | | | 0.007 | | |
| | (0.014) | | | (0.009) | | | (0.016) | | |
| e_sell | | -0.054 | | | -0.014 | | | -0.061 | |
| | | (0.017)*** | | | (0.010) | | | (0.020)*** | |
| e_buy | | 0.077 | | | 0.025 | | | 0.089 | |
| | | (0.017)*** | | | (0.010)** | | | (0.019)*** | |
| sell_no_buy | | | -0.052 | | | -0.019 | | | -0.061 |
| | | | (0.021)** | | | (0.011)* | | | (0.024)** |
| buy_no_sell | | | 0.081 | | | 0.016 | | | 0.088 |
| | | | (0.026)*** | | | (0.017) | | | (0.028)*** |
| buy_sell | | | 0.022 | | | 0.012 | | | 0.029 |
| | | | (0.018) | | | (0.012) | | | (0.020) |
| UK MNE | 0.143 | 0.142 | 0.142 | 0.026 | 0.026 | 0.026 | 0.079 | 0.079 | 0.079 |
| | (0.023)*** | (0.023)*** | (0.023)*** | (0.012)** | (0.012)** | (0.012)** | (0.024)*** | (0.024)*** | (0.024)*** |
| US MNE | 0.278 | 0.274 | 0.274 | 0.071 | 0.070 | 0.070 | 0.140 | 0.135 | 0.135 |
| | (0.036)*** | (0.036)*** | (0.036)*** | (0.017)*** | (0.017)*** | (0.017)*** | (0.032)*** | (0.032)*** | (0.032)*** |
| OTHER MNE | 0.195 | 0.191 | 0.191 | 0.032 | 0.031 | 0.031 | 0.034 | 0.030 | 0.030 |
| | (0.031)*** | (0.031)*** | (0.031)*** | (0.014)** | (0.014)** | (0.014)** | (0.031) | (0.031) | (0.031) |
| ln_emp | 0.087 | 0.088 | 0.088 | 0.015 | 0.015 | 0.015 | 0.045 | 0.045 | 0.045 |
| | (0.008)*** | (0.007)*** | (0.007)*** | (0.004)*** | (0.004)*** | (0.004)*** | (0.008)*** | (0.008)*** | (0.008)*** |
| Age | 0.006 | 0.006 | 0.006 | 0.009 | 0.009 | 0.009 | -0.004 | -0.005 | -0.005 |
| | (0.007) | (0.007) | (0.007) | (0.005)** | (0.005)* | (0.005)* | (0.008) | (0.008) | (0.008) |
| age2 | -0.000 | -0.000 | -0.000 | -0.000 | -0.000 | -0.000 | 0.000 | 0.000 | 0.000 |
| | (0.000) | (0.000) | (0.000) | (0.000)* | (0.000)* | (0.000)* | (0.000) | (0.000) | (0.000) |
| age_cens | -0.030 | -0.030 | -0.030 | 0.036 | 0.036 | 0.036 | -0.005 | -0.005 | -0.005 |
| | (0.040) | (0.040) | (0.040) | (0.023) | (0.023) | (0.023) | (0.047) | (0.047) | (0.047) |
| ln_k_emp | | | | 0.088 | 0.088 | 0.088 | 0.303 | 0.303 | 0.303 |
| | | | | (0.011)*** | (0.011)*** | (0.011)*** | (0.015)*** | (0.015)*** | (0.015)*** |
| ln_mat_emp | | | | 0.614 | 0.614 | 0.614 | | | |
| | | | | (0.014)*** | (0.014)*** | (0.014)*** | | | |
| Observations | 9316 | 9316 | 9316 | 5544 | 5544 | 5544 | 5438 | 5438 | 5438 |
| R-squared | 0.21 | 0.21 | 0.21 | 0.81 | 0.81 | 0.81 | 0.33 | 0.33 | 0.33 |

**Table 6.2**

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|---|
| all firms | LP | | | TFP | | | | | |
| 2000 & 2001 | Dependent variable: value added | | | Dependent variable: gross output | | | Dependent variable: value added | | |
| buy_or_sell | 0.024 | | | -0.001 | | | 0.007 | | |
| | (0.011)** | | | (0.007) | | | (0.012) | | |
| e_sell | | -0.037 | | | -0.014 | | | -0.050 | |
| | | (0.012)*** | | | (0.008)* | | | (0.014)*** | |
| e_buy | | 0.074 | | | 0.024 | | | 0.071 | |
| | | (0.012)*** | | | (0.008)*** | | | (0.014)*** | |
| sell_no_buy | | | -0.027 | | | -0.024 | | | -0.049 |
| | | | (0.015)* | | | (0.009)*** | | | (0.017)*** |
| buy_no_sell | | | 0.089 | | | 0.007 | | | 0.073 |
| | | | (0.018)*** | | | (0.014) | | | (0.021)*** |
| buy_sell | | | 0.034 | | | 0.013 | | | 0.021 |
| | | | (0.013)*** | | | (0.008) | | | (0.015) |
| ln_emp | 0.113 | 0.114 | 0.113 | 0.018 | 0.018 | 0.018 | 0.055 | 0.055 | 0.055 |
| | (0.005)*** | (0.005)*** | (0.005)*** | (0.003)*** | (0.003)*** | (0.003)*** | (0.006)*** | (0.006)*** | (0.006)*** |
| Age | 0.012 | 0.012 | 0.012 | 0.010 | 0.010 | 0.010 | 0.002 | 0.002 | 0.002 |
| | (0.005)** | (0.005)** | (0.005)** | (0.003)*** | (0.003)*** | (0.003)*** | (0.006) | (0.006) | (0.006) |
| age2 | -0.000 | -0.000 | -0.000 | -0.000 | -0.000 | -0.000 | -0.000 | 0.000 | 0.000 |
| | (0.000)** | (0.000)** | (0.000)** | (0.000)*** | (0.000)*** | (0.000)*** | (0.000) | (0.000) | (0.000) |
| age_cens | -0.002 | -0.001 | -0.001 | 0.032 | 0.033 | 0.033 | -0.008 | -0.007 | -0.007 |
| | (0.029) | (0.029) | (0.029) | (0.018)* | (0.018)* | (0.018)* | (0.036) | (0.036) | (0.036) |
| ln_k_emp | | | | 0.084 | 0.084 | 0.084 | 0.288 | 0.287 | 0.287 |
| | | | | (0.009)*** | (0.009)*** | (0.009)*** | (0.011)*** | (0.011)*** | (0.011)*** |
| ln_mat_emp | | | | 0.611 | 0.611 | 0.611 | | | |
| | | | | (0.010)*** | (0.010)*** | (0.010)*** | | | |
| Observations | 17671 | 17671 | 17671 | 11660 | 11660 | 11660 | 11437 | 11437 | 11437 |
| R-squared | 0.20 | 0.20 | 0.20 | 0.83 | 0.83 | 0.83 | 0.33 | 0.33 | 0.33 |

**Table 6.3**

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|---|
| Small | LP | | | TFP | | | | | |
| 2000 & 2001 | Dependent variable: value added | | | Dependent variable: gross output | | | Dependent variable: value added | | |
| buy_or_sell | 0.037 | | | -0.008 | | | 0.016 | | |
| | (0.017)** | | | (0.015) | | | (0.024) | | |
| e_sell | | -0.014 | | | -0.028 | | | -0.034 | |
| | | (0.020) | | | (0.018) | | | (0.028) | |
| e_buy | | 0.063 | | | 0.023 | | | 0.061 | |
| | | (0.021)*** | | | (0.020) | | | (0.030)** | |
| sell_no_buy | | | -0.001 | | | -0.031 | | | -0.030 |
| | | | (0.025) | | | (0.021) | | | (0.036) |
| buy_no_sell | | | 0.085 | | | 0.019 | | | 0.067 |
| | | | (0.030)*** | | | (0.031) | | | (0.042) |
| buy_sell | | | 0.044 | | | -0.003 | | | 0.025 |
| | | | (0.021)** | | | (0.019) | | | (0.029) |
| ln_emp | 0.152 | 0.154 | 0.153 | 0.026 | 0.026 | 0.026 | 0.077 | 0.078 | 0.078 |
| | (0.012)*** | (0.012)*** | (0.012)*** | (0.010)*** | (0.010)*** | (0.010)*** | (0.016)*** | (0.016)*** | (0.016)*** |
| Age | 0.013 | 0.013 | 0.013 | 0.025 | 0.025 | 0.025 | 0.009 | 0.009 | 0.009 |
| | (0.008) | (0.008) | (0.008) | (0.007)*** | (0.007)*** | (0.007)*** | (0.011) | (0.011) | (0.011) |
| age2 | -0.001 | -0.001 | -0.001 | -0.001 | -0.001 | -0.001 | -0.000 | -0.001 | -0.001 |
| | (0.000)* | (0.000)* | (0.000)* | (0.000)*** | (0.000)*** | (0.000)*** | (0.001) | (0.001) | (0.001) |
| age_cens | 0.059 | 0.061 | 0.060 | 0.092 | 0.095 | 0.095 | 0.059 | 0.064 | 0.064 |
| | (0.051) | (0.051) | (0.051) | (0.046)** | (0.046)** | (0.046)** | (0.088) | (0.088) | (0.088) |
| ln_k_emp | | | | 0.091 | 0.091 | 0.091 | 0.290 | 0.290 | 0.290 |
| | | | | (0.017)*** | (0.017)*** | (0.017)*** | (0.017)*** | (0.017)*** | (0.017)*** |
| ln_mat_emp | | | | 0.588 | 0.588 | 0.588 | | | |
| | | | | (0.018)*** | (0.018)*** | (0.018)*** | | | |
| Observations | 8224 | 8224 | 8224 | 4053 | 4053 | 4053 | 3936 | 3936 | 3936 |
| R-squared | 0.18 | 0.18 | 0.18 | 0.80 | 0.80 | 0.80 | 0.34 | 0.34 | 0.34 |

**Table 6.4**

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|---|
| big firms | LP | | | TFP | | | | | |
| 2000 & 2001 | Dependent variable: value added | | | Dependent variable: gross output | | | Dependent variable: value added | | |
| buy_or_sell | 0.017 | | | 0.004 | | | 0.005 | | |
| | (0.013) | | | (0.008) | | | (0.014) | | |
| e_sell | | -0.048 | | | -0.007 | | | -0.060 | |
| | | (0.014)*** | | | (0.008) | | | (0.016)*** | |
| e_buy | | 0.080 | | | 0.024 | | | 0.079 | |
| | | (0.014)*** | | | (0.007)*** | | | (0.015)*** | |
| sell_no_buy | | | -0.043 | | | -0.017 | | | -0.058 |
| | | | (0.017)** | | | (0.009)* | | | (0.019)*** |
| buy_no_sell | | | 0.088 | | | 0.006 | | | 0.082 |
| | | | (0.023)*** | | | (0.015) | | | (0.023)*** |
| buy_sell | | | 0.031 | | | 0.019 | | | 0.019 |
| | | | (0.015)** | | | (0.008)** | | | (0.017) |
| ln_emp | 0.093 | 0.092 | 0.092 | 0.017 | 0.017 | 0.017 | 0.062 | 0.061 | 0.061 |
| | (0.009)*** | (0.009)*** | (0.009)*** | (0.004)*** | (0.004)*** | (0.004)*** | (0.010)*** | (0.010)*** | (0.010)*** |
| Age | 0.003 | 0.003 | 0.003 | -0.000 | -0.000 | -0.000 | -0.002 | -0.002 | -0.002 |
| | (0.006) | (0.006) | (0.006) | (0.003) | (0.003) | (0.003) | (0.007) | (0.007) | (0.007) |
| age2 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) |
| age_cens | -0.078 | -0.079 | -0.079 | -0.019 | -0.018 | -0.018 | -0.055 | -0.057 | -0.057 |
| | (0.034)** | (0.034)** | (0.034)** | (0.017) | (0.017) | (0.017) | (0.039) | (0.039) | (0.039) |
| ln_k_emp | | | | 0.086 | 0.086 | 0.086 | 0.283 | 0.282 | 0.282 |
| | | | | (0.009)*** | (0.009)*** | (0.009)*** | (0.015)*** | (0.015)*** | (0.015)*** |
| ln_mat_emp | | | | 0.625 | 0.624 | 0.624 | | | |
| | | | | (0.011)*** | (0.011)*** | (0.011)*** | | | |
| Observations | 9447 | 9447 | 9447 | 7607 | 7607 | 7607 | 7501 | 7501 | 7501 |
| R-squared | 0.25 | 0.26 | 0.26 | 0.86 | 0.86 | 0.86 | 0.36 | 0.36 | 0.36 |

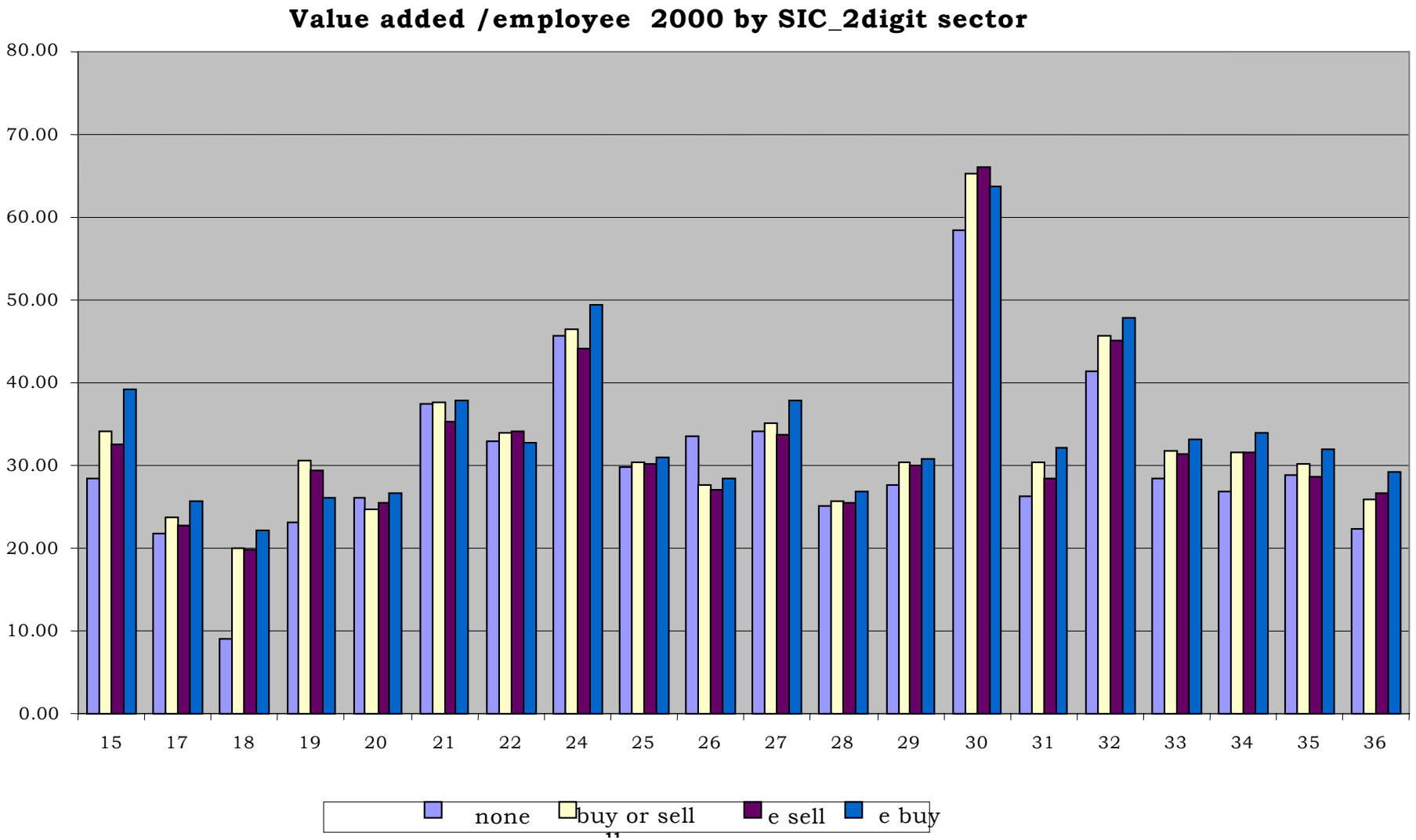
**Table 6.5**

| 2000 | | none | either | Sell | buy | Sell no buy | Buy no Sell | Buy and Sell |
|---|---|---|---|---|---|---|---|---|
| GO/EMP | Obs | 4825 | 3696 | 3055 | 2349 | 1347 | 641 | 1708 |
| | Mean | 91.45 | 100.71 | 100.09 | 107.94 | 88.10 | 103.66 | 109.55 |
| | Med | 61.33 | 68.82 | 67.22 | 70.33 | 65.82 | 77.97 | 68.84 |
| | Sd | 197.76 | 146.77 | 153.60 | 171.62 | 86.62 | 108.48 | 189.98 |
| VA/EMP | Obs | 4825 | 3696 | 3055 | 2349 | 1347 | 641 | 1708 |
| | Mean | 29.63 | 32.50 | 31.72 | 34.45 | 29.09 | 36.19 | 33.80 |
| | Med | 24.74 | 26.54 | 26.11 | 27.63 | 24.73 | 28.79 | 27.21 |
| | Sd | 33.13 | 32.15 | 30.06 | 36.45 | 22.40 | 40.47 | 34.81 |
| emp | Obs | 5262 | 4001 | 3321 | 2528 | 1473 | 680 | 1848 |
| | Mean | 129 | 260 | 256 | 278 | 228 | 279 | 278 |
| | Med | 40 | 84 | 84 | 78 | 95 | 82 | 76 |
| | Sd | 343 | 729 | 664 | 845 | 466 | 987 | 787 |
| | | | | | | | | |
| 2001 | | none | either | Sell | buy | Sell no buy | Buy no Sell | Buy and Sell |
| GO/EMP | Obs | 4917 | 4587 | 3705 | 3089 | 1498 | 882 | 2207 |
| | Mean | 98.69 | 104.83 | 103.15 | 110.86 | 92.39 | 111.89 | 110.44 |
| | Med | 61.54 | 71.93 | 70.60 | 73.66 | 68.26 | 77.77 | 72.40 |
| | Sd | 325.96 | 201.32 | 215.72 | 235.59 | 97.20 | 123.60 | 267.56 |
| VA/EMP | Obs | 4917 | 4587 | 3705 | 3089 | 1498 | 882 | 2207 |
| | Mean | 31.61 | 33.16 | 32.39 | 34.51 | 30.36 | 36.36 | 33.77 |
| | Med | 24.80 | 27.88 | 27.41 | 28.84 | 25.95 | 30.28 | 28.53 |
| | Sd | 89.89 | 34.37 | 33.25 | 37.97 | 25.14 | 38.55 | 37.73 |
| emp | Obs | 5359 | 4913 | 3982 | 3308 | 1605 | 931 | 2377 |
| | Mean | 113 | 232 | 237 | 246 | 202 | 208 | 261 |
| | Med | 32 | 72 | 73 | 69 | 80 | 68 | 69 |
| | Sd | 343 | 619 | 642 | 690 | 436 | 504 | 749 |

**Table 6.6**

| 2000: average value added per employee by industry and type of e-commerce activity (obs: reports number of obs on which mean is calculated. | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| sic92 2digit | 15 | 17 | 18 | 19 | 20 | 21 | 22 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 | 34 | 35 | 36 |
| obs | 407 | 217 | 97 | 39 | 153 | 165 | 385 | 303 | 304 | 214 | 213 | 666 | 564 | 39 | 212 | 106 | 165 | 127 | 141 | 271 |
| No e-commerce | 28.43 | 21.79 | 9.07 | 23.09 | 26.03 | 37.45 | 32.86 | 45.57 | 29.90 | 33.55 | 34.17 | 25.20 | 27.66 | 58.32 | 26.25 | 41.31 | 28.50 | 26.91 | 28.82 | 22.32 |
| obs | 429 | 167 | 74 | 29 | 58 | 140 | 383 | 245 | 238 | 123 | 120 | 345 | 343 | 65 | 190 | 117 | 171 | 157 | 83 | 210 |
| e-buy or sell | 34.09 | 23.73 | 19.96 | 30.52 | 24.66 | 37.54 | 33.89 | 46.47 | 30.35 | 27.61 | 35.15 | 25.68 | 30.33 | 65.28 | 30.38 | 45.68 | 31.81 | 31.67 | 30.19 | 25.79 |
| obs | 383 | 138 | 64 | 25 | 48 | 115 | 342 | 196 | 204 | 97 | 102 | 291 | 261 | 46 | 152 | 89 | 115 | 142 | 56 | 182 |
| e sell | 32.64 | 22.82 | 19.93 | 29.38 | 25.47 | 35.27 | 34.16 | 44.17 | 30.11 | 27.03 | 33.79 | 25.50 | 30.06 | 65.92 | 28.47 | 45.14 | 31.40 | 31.49 | 28.67 | 26.59 |
| obs | 201 | 102 | 41 | 13 | 39 | 84 | 256 | 173 | 140 | 74 | 63 | 203 | 255 | 58 | 125 | 96 | 139 | 99 | 67 | 116 |
| e buy | 39.12 | 25.63 | 22.24 | 26.19 | 26.71 | 37.81 | 32.70 | 49.31 | 30.95 | 28.41 | 37.87 | 26.86 | 30.74 | 63.57 | 32.10 | 47.79 | 33.10 | 33.83 | 31.99 | 29.20 |

**Figure 6.2**


Value added /employee 2000 by SIC_2digit sector
80.00
70.00
60.00
50.00
40.00
30.00
20.00
10.00
0.00
15
17
18
19
20
21
22
24
25
26
27
28
29
30
31
32
33
34
35
36
none
buy or sell
e sell
e buy

# 7 Price effects

## *7.1 Outline*

Productivity analysis based on the ABI for UK manufacturing sectors shows that in most, but not all, industries covered there are positive value added effects associated with purchasing via electronic networks, and partial offsetting negative effect associated with selling. The suggestion from EU sponsored case studies is that price differences brought about by e-procurement are part of the 'value added' gain to firms which invest in use of electronic networks. This section reports preliminary discussions with industry experts, looks briefly at prior evidence on price effects of electronic markets, and tests the scope for detecting price differences by using official price statistics data linked to e-commerce survey information.

## *7.2 Firm discussions*

Interviews with firms which provide the infrastructure and databases on which electronic transaction systems are based have confirmed that gains through the management of backward supply chains are among the most important ex-ante justifications for investment for firms. The sources of cost saving for them are both internal and external, reducing the search and administrative costs associated with buying, and reducing purchase prices through access to a broader and better specified set of suppliers.

One system supplier specialist interviewed qualified the experience of price effects by commenting that in their experience the effect of electronic buying and selling depends on the relative numbers of buyers and sellers, as well on the nature of the transactions. In markets where there are a large number of sellers making sales propositions to fewer buyers, the most likely outcome is downward pressure on prices, but where a larger number of buyers faces a small number of sellers the effect of electronic networks is to exert upward pressure on prices. These considerations were said to affect the design of buying / selling networks.

## *7.3 Evidence from other sources*

Literature on the price effects of digital markets (reviewed in Smith, Bailey and Brynjolfsson) covers a complex set of possible effects, which depend on the types of transactions covered.

- For simple products which can be specified in relatively few dimensions, electronic markets may increase price transparency and commoditisation, raising the importance of price in buying decisions which may tend to push prices down. For more complex products, where differentiation is possible there may be added scope, through the one to one relationship between buyer and seller permitted by e-commerce, for price discrimination based on specific buyer circumstances, increasing both price dispersion and level.
- Electronic transactions may affect market boundaries in opposite ways. Lower search costs for buyers may enable them to seek more suppliers, tipping the balance of supply and demand in their favour and edging prices down. On the other hand, the investment required by suppliers in some EDI type closed electronic purchasing systems may limit entry, reducing scope for competition; but once made such investment may act as a barrier to exit, so that competition in supply increases over time.

- E-commerce can also change the nature of transactions. Adoption of systematised e-procurement models by firms often changes relationships with suppliers from a negotiation process towards long term agreement into a series of auctions and bids for specific, shorter term, contracts which are likely to be more intensely competitive. Against this, use of electronic networks for purposes in addition to the purchase decision can facilitate the delivery of value added services as part of a more intimate partnership between suppliers and customers in the value chain.
- The most dramatic effects of e-commerce can arise when suppliers use it to sell direct to their end users, cutting out a stage in the distribution chain; the best know example if this is Dell computers, selling direct to consumers and by-passing PC retailers
- As a further difference between electronic sales and traditional marketing approaches, the ability of suppliers to change prices quickly and cheaply using web-based price lists should be substantially greater. For example, traditional catalogue selling organisations were once restricted to changing prices, with their catalogues, two or three times a year to avoid unacceptably high marketing costs; with web based selling they can change prices from day to day, and aim special offers at selected customers whose buying patterns are known to them. Greater price flexibility and speed of response to shocks may be expected

Most of these effects have been identified, but not often quantified, in the OECD E-Business Impact Programme (EBIP) which brings together e-commerce experiences from a number of countries (see www.oecd.org/sti/information-economy). The quantified evidence quoted by Smith Bailey and Brynjolfsson tends to come from consumer internet markets (which still account for a small minority of e-commerce in the UK) rather than from digital business to business markets. This evidence seems to suggest that consumer prices are as likely to have risen as to have fallen over the internet, and that price dispersion has, on the whole, been unaffected.

### *7.4 UK survey data*

Based on our results from section 6, using ABI data to identify large numbers of manufacturing businesses which do, and do not, use electronic networks for selling, we are able to test the behaviour of prices in UK firms as a function of their use of e-commerce, mainly in business to business markets. So far, we have conducted only a limited test covering firms identified for the year 2000, but one which suggests that results are statistically significant and worth further investigation as additional years' data become available.

To undertake this analysis, the following indirect data linking exercise has been undertaken. From the ABI responses to the e-commerce questions outlined in section 3, the use / non use of electronic networks for selling has been identified for firms in 40 SIC sectors and sub-sectors in which e-commerce is known to be used by a significant proportion of firms. Through identifiers from the UK business register (IDBR) the firms have been matched with those that respond to the monthly UK producer price inquiry (PPI). This inquiry asks a large number of firms for quotes for specific, detailed, products on a consistent basis.

PPI results are summarised in a database which capture monthly movements for the prices returned, corrected for any changes in quality specification which occur. Based on January 1995 = 100, the 'price relatives' for each specified product show its

movement since the base date. These are weighted together according to value of output from each respondent to develop the UK Producer Price Index data-set.

For this analysis we are only able to identify firms that sell electronically in the year 2000, not the specific products they sell over electronic networks, or the year in which they might have started selling over electronic networks. To test for possible differences, the first approach has been to separate the PPI sets for firms which do, and do not, sell electronically within each SIC, taking the firm identifier as the definition of industrial classification (which may not be the same classification as the products quoted). We have then weighted the price relatives equally within the two sets (e-sell and non e-sell), because we are concerned to identify possible differences between trends in individual observations the two sets of data than to reproduce the Producer Price Indices. Only in about 30% of cases do the two data-sets (PPI and ABI) overlap, so the price data is only available for a partial set of the forms on which our productivity evidence is based

The results are shown in figures 7.1 to 7.6, with specific sectors shown as examples. Each graph shows the evolution of average price relative data for e-sellers and for non e-sellers month by month over the period January 1997 to December 2000. Each individual price relative series is based on January 1995 = 100, and the individual series are equally weighted to produce the average. They appear to show different effects in different markets, and we have grouped them into five main patterns of price behaviour over time.

*i) sectors where prices diverge in the period, with e-sellers' prices falling relative to non e-sellers*.
This group (Figure 7.1)includes pharmaceuticals manufacture (177 firms observed), where e-commerce systems have been adopted by major pharmaceutical wholesalers over the period as part of the process of increasing competition in a regulate market. It also includes mechanical engineering (32 firms observed), which is a relatively heterogeneous sector subject to increasing international competition over the period.

*ii) sectors where e-sellers' non e-sellers' prices diverged between 1995 and 1997, and where e-sellers prices remained lower through to 2000.*
This group (Figure 7.2)includes food products in both meat processing (125 observations) and bakery production (67 observations) which sell a large part of their output to supermarkets, all of whom have used electronic procurement systems based on closed (EDI) systems for some time.

*iii) sectors where e-sellers prices had fallen relative to non e-sellers prior to 1997, and appear to re-converge by 2000*
This group (Figure 7.3) includes basic organic chemicals (191 observations) and pesticides and agrochemical products (41 observations). In both these sectors there are effectively global markets, and there has been substantial international consolidation of supply during the later 1990s. These sectors are also subject to input price shocks from the oil market, to which they adjust with varying degrees of speed.

*iv) sectors where prices for the two groups are indistinguishable*
This group (Figure 7.4) includes electronic components (137 observations) and newspaper publishing (118 observations), both areas related to sectors where e-

commerce is well established, and has influenced markets for considerable time. In such markets it is possible that competition has ensured that prices have stayed aligned. It is worth noting that in our productivity analysis by sector in section 6, publishing and computer manufacture were the two sectors in which value added / employee productivity measures for e-sellers were higher than for e-buyers. This would be consistent with a situation in which selling prices for e-sellers and non e-sellers were similar, and productivity gains associated with electronic network use were retained by firms rather than being passed on to customers through lower prices.

*v) sectors where e-sellers' prices are higher than non e-sellers'*
This group (Figure 7.5) includes manufacture of parts for motor vehicles (148 observations) and manufacture of soap and detergents (58 observations). These are both sectors where intermediate demand includes both major brand owners who purchase for inclusion into branded consumer products, and 'spot' demand for other applications. It may be that differences in service levels or specification account for the differences.

We have also encountered one sector, paints and varnishes, shown in Figure 7.6 and containing 136 observations, where e-sellers' prices have increased relative to non e-sellers' over the four year period covered. This is a sector where there are major differences in price levels between consumer and industrial products, and where there have been technology developments in service delivery as well as producer consolidation over the period.

## *7.5 Conclusions*

UK price evidence from this limited set supports the view from the literature that a range of forces are at work to affect prices in electronic markets. Across all the 21 groups examined, sectors in which e-sellers' prices are lower (groups i to iii) outnumber those where there is no difference, or where e-sellers' prices are higher. Overall therefore, it seems that the electronic sale of goods is more likely to have a negative impact on prices but there is a great deal of variation.

This conclusion is supported by regression analysis for 2400 reported price series across forty four digit sectors in manufacturing for which we have data, each series monthly over four years. The results are presented in Table 7.1, and the sectors listed in Table 7.2. They suggest that the electronic receipt of orders has a negative impact on relative prices which is statistically significant at the ten per cent level, after taking sector and size effects into account. The sample contains all firm level observations of relative prices for the selected sectors between January 1997 and December 2000 where real responses are available. Monthly price trends, and sector effects have been controlled for using monthly and industry dummies, the latter using four digit SIC codes. Firm size is measured by employment, but the equation works almost equally well using sales or market share.

The model based on this initial data provides a reasonable “fit” with an R-squared of 0.3 allowing for the fact that no other determinants of prices have been included. An attempt has been made to look at the 'number of suppliers' factors suggested by our industry interviewees, taking sector concentration (share of top four producers) or Herfindahl index into the analysis. This has been attempted in both the regression analysis, and in graphical analysis. In neither case does a clear pattern emerge -

probably because other factors covered in the literature - concentration in customer industries, presence of value added services or effect on distribution channels - are absent from our data-sets.

Our provisional conclusion is that price effect of e-commerce in the sectors we have examined for the period up to 2000 is, on balance negative, and that this is consistent with the value added effects we see in productivity data. It is clear that effects differ across sectors, and in some sectors the effects of competition appear to even out price effects within a few years. However, the overall effect is to make the majority of markets more price competitive, which is likely to have both micro and macro effects within the economy. At micro level e-commerce is likely to speed up the selection processes favouring more efficient firms, and at macro level the evidence suggests that it may increase competitive downward pressure on prices.

**Table 7.1**

**Regression results for effect of e-selling on producer prices (limited sample, 1997-2000)**

Dependent variable: Relative Price

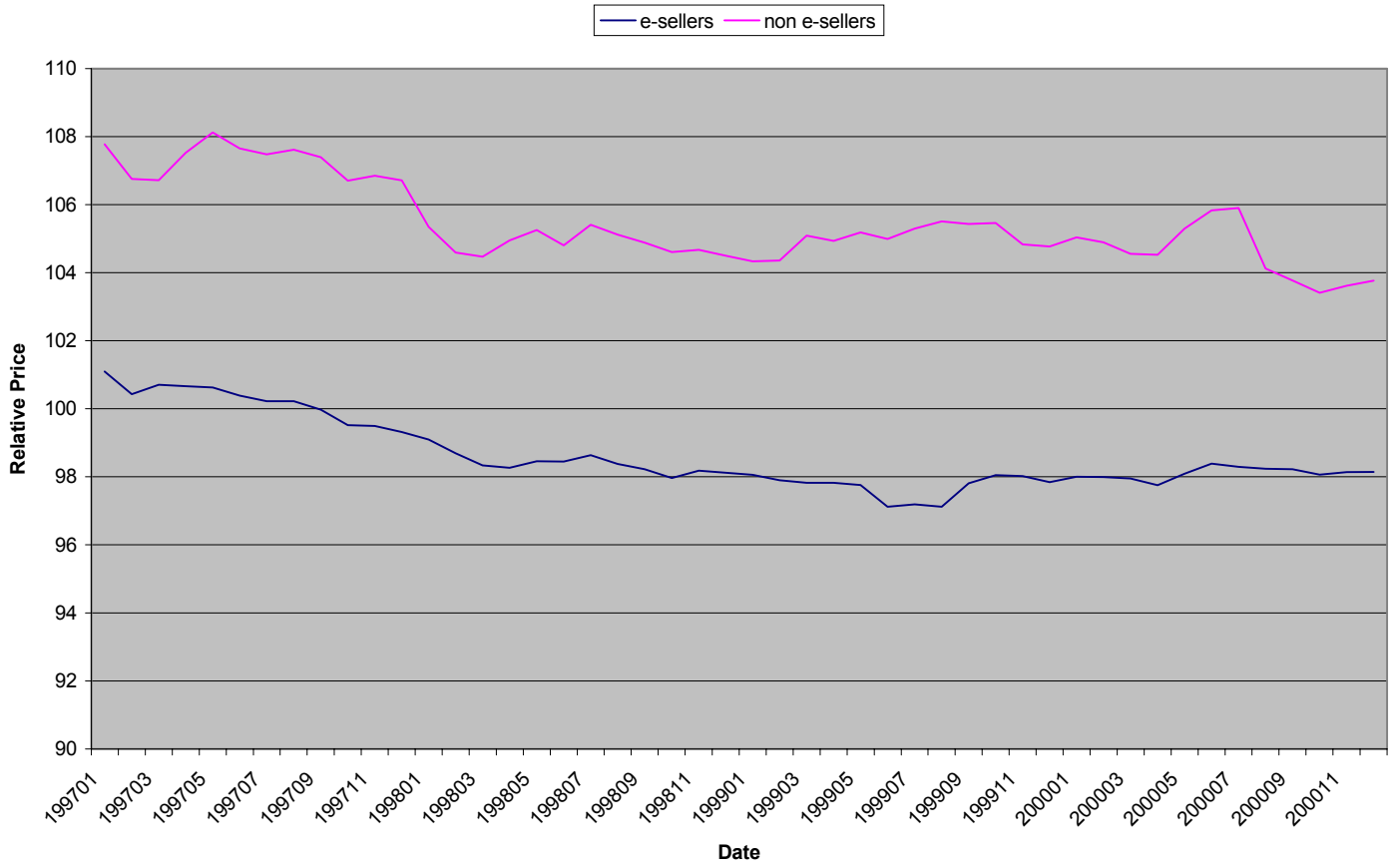
| Variable | Coefficient (P value) |
|---|---|
| e-sell | -1.352813 |
| | (0.099)* |
| Employment | -0.0007413 |
| | (0.136) |
| Intercept | 106.2562 |
| | (0)*** |
| Observations | 107201 |
| Adjusted R-squared | 0.2979 |

*** Significant at 1% level
** Significant at 5% level
* Significant at10% level

Table 7.2
Sectors covered by analysis so far

| 4 digit SIC | Description of sectors for which we have firms with observations from ABI which establish e-commerce use / non-use, plus time series of producer price relative data. | Average number of time series in firms from SIC category |
|---|---|---|
| 1513 | Production of meat and poultry meat products | 125 |
| 1581 | Manufacture of bread; manufacture of fresh pastry goods and cakes | 67 |
| 2121 | Manufacture of corrugated paper and paperboard and of containers of paper and paperboard | 121 |
| 2211 | Publishing of books | 72 |
| 2212 | Publishing of newspapers | 120 |
| 2213 | Publishing of journals and periodicals | 104 |
| 2214 | Publishing of sound recordings | <10 |
| 2215 | Other publishing | 20 |
| 2221 | Printing of newspapers | <10 |
| 2222 | Printing not elsewhere classified | 135 |
| 2223 | Bookbinding and finishing | <10 |
| 2224 | Composition and plate-making | 12 |
| 2225 | Other activities related to printing | <10 |
| 2231 | Reproduction of sound recording | 19 |
| 2232 | Reproduction of video recording | 16 |
| 2233 | Reproduction of computer media | <10 |
| 2411 | Manufacture of industrial gases | 11 |
| 2412 | Manufacture of dyes and pigments | 37 |
| 2413 | Manufacture of other inorganic basic chemicals | 95 |
| 2414 | Manufacture of other organic basic chemicals | 200 |
| 2415 | Manufacture of fertilizers and nitrogen compounds | 38 |
| 2416 | Manufacture of plastics in primary forms | 129 |
| 2417 | Manufacture of synthetic rubber in primary forms | 10 |
| 2420 | Manufacture of pesticides and other agro-chenmical products | 47 |
| 2430 | Manufacture of paints, varnishes and similar coatings, printing ink and mastics | 161 |
| 2441 | Manufacture of basic pharmaceuticals | 30 |
| 2442 | Manufacture of pharmaceutical preparations | 165 |
| 2451 | Manufacture of soap and detergents, cleaning and polishing preparations | 67 |
| 2452 | Manufacture of perfumes and toilet preparations | 98 |
| 2461 | Manufacture of explosives | 16 |
| 2462 | Manufacture of glues and gelatine | 22 |
| 2463 | Manufacture of essential oils | 38 |
| 2464 | Manufacture of photographic chemical material | 17 |
| 2465 | Manufacture of prepared recorded media | 13 |
| 2466 | Manufacture of other chemical products not elsewhere classified | 79 |
| 2470 | Manufacture of man-made fibres | 29 |
| 2523 | Manufacture of builders' ware of plastic | 80 |
| 2852 | General Mechanical Engineering | 32 |
| 3210 | Manufacture of electronic valves and tubes and other electronic components | 141 |
| 3430 | Manufacture of parts and accessories for motor vehicles and their engines | 147 |

**Figure 7.1**
**1513 Production of meat & poultry products**




**1581 Manufacture of bread; manufacture of fresh pastry goods and cakes**

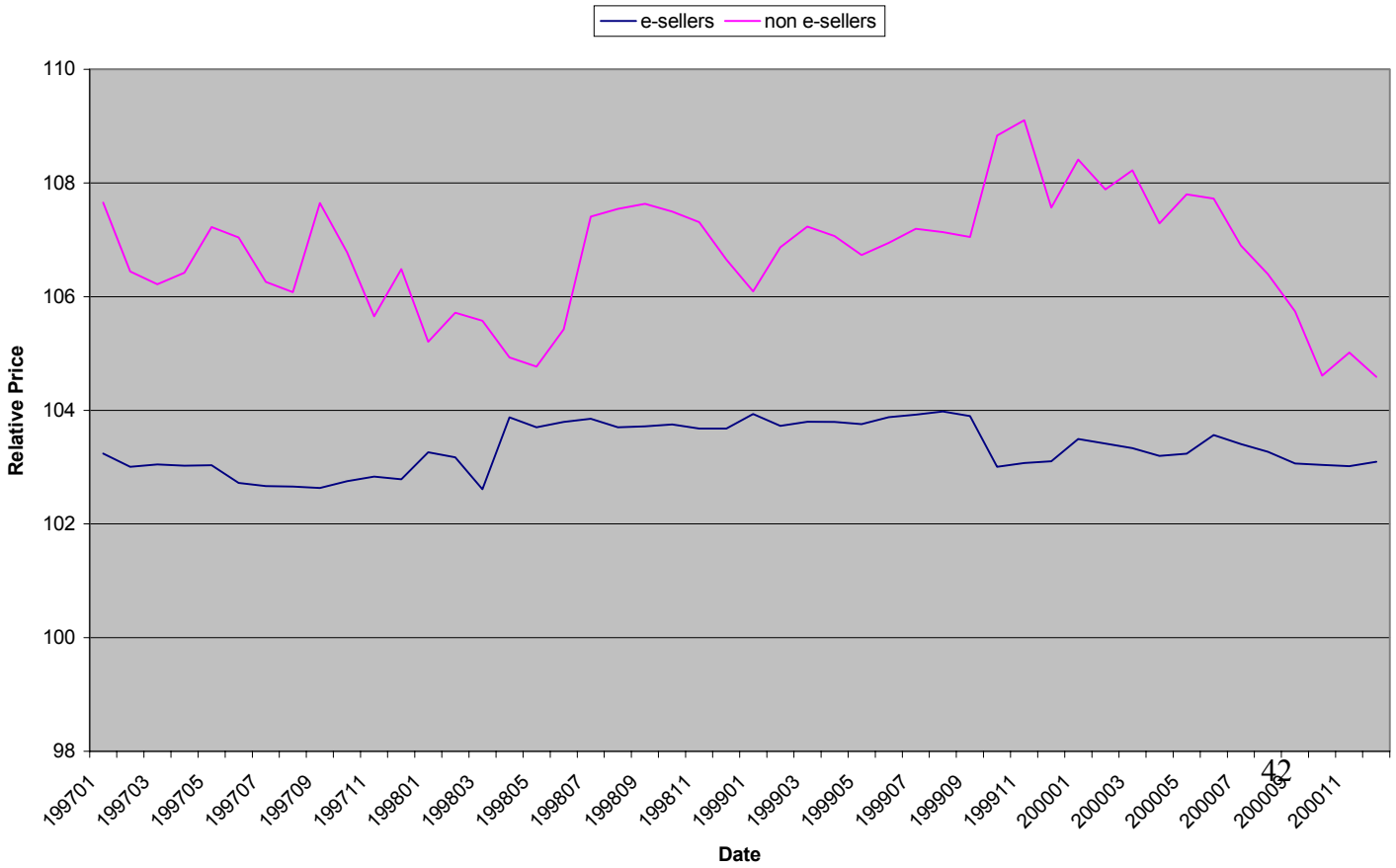
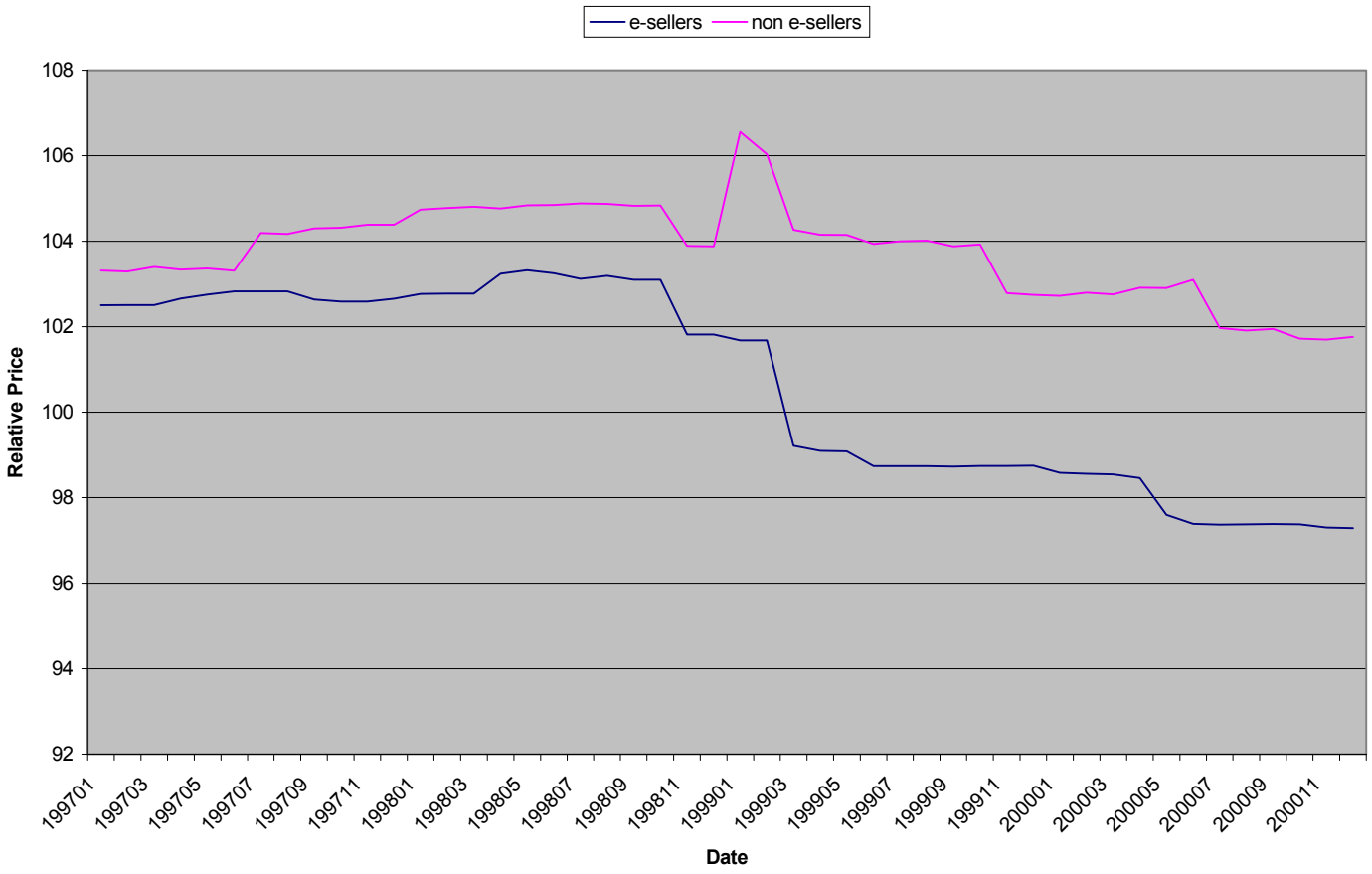


**Figure 7.2**

**2852 General Mechanical Engineering**




**2442 Manufacture of pharmaceutical preparations**

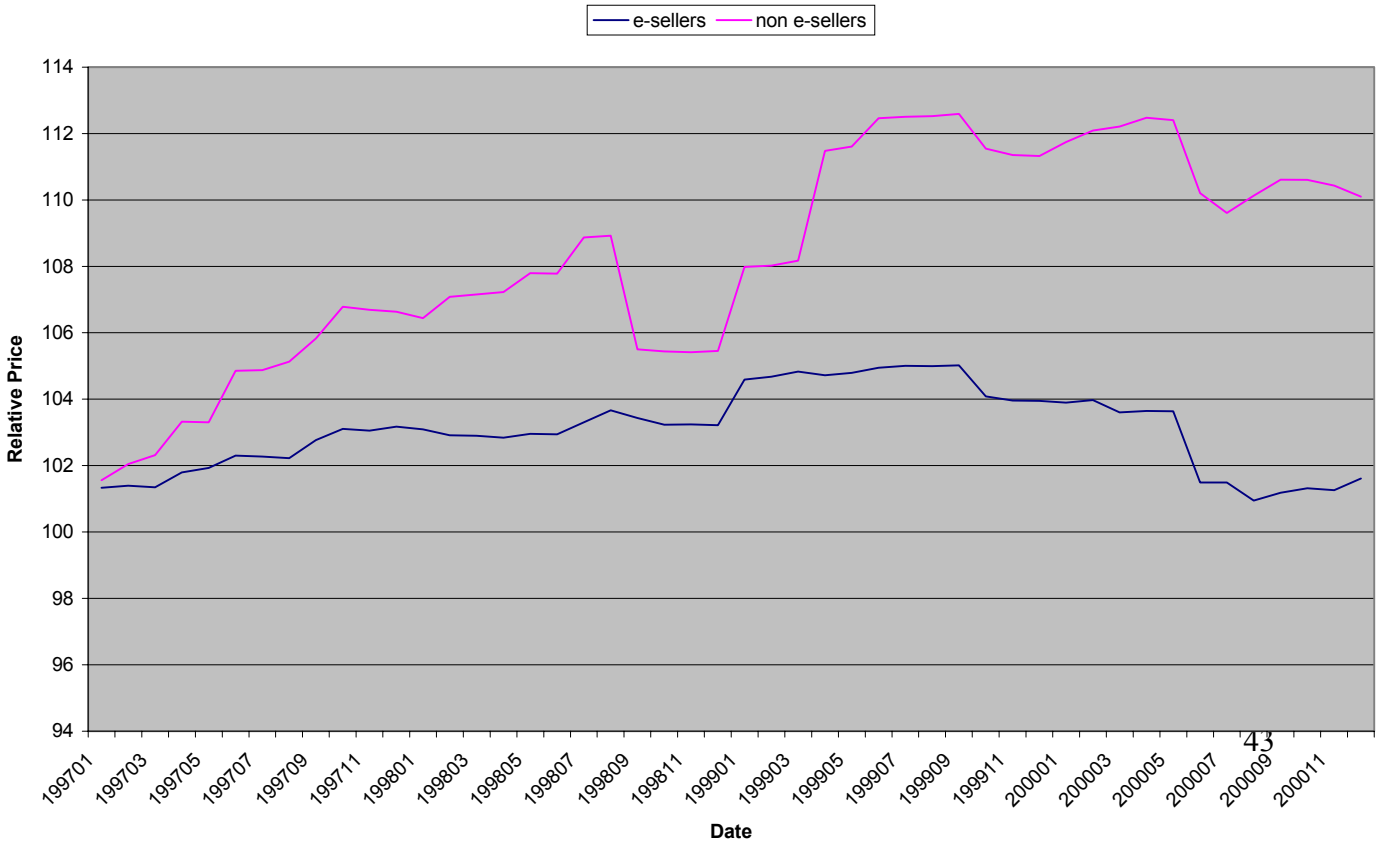
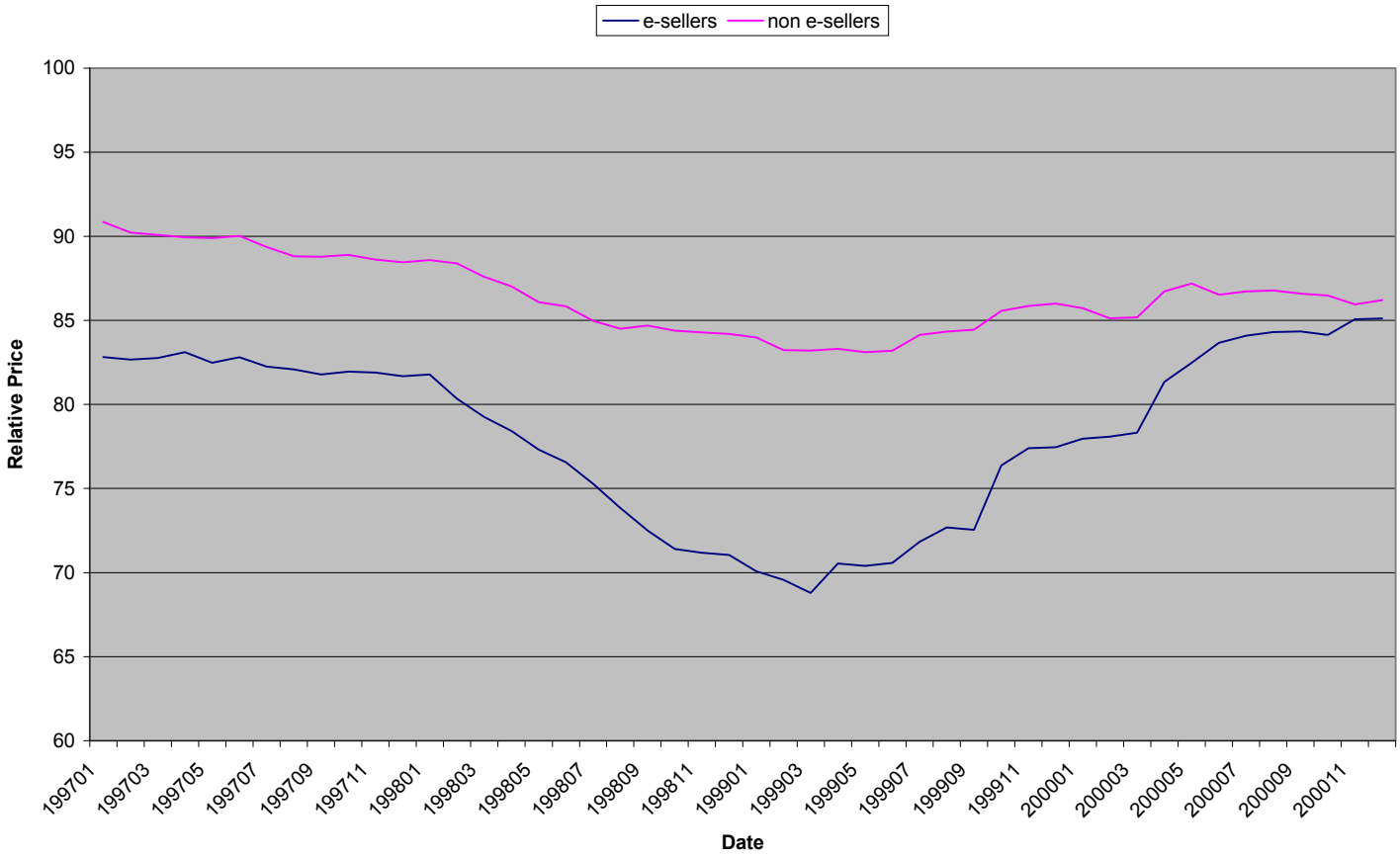


**Figure 7.3**
**2414 Manufacture of other inorganic chemicals**




**2420 Manufacture of pesticides and other agro-chemical products**

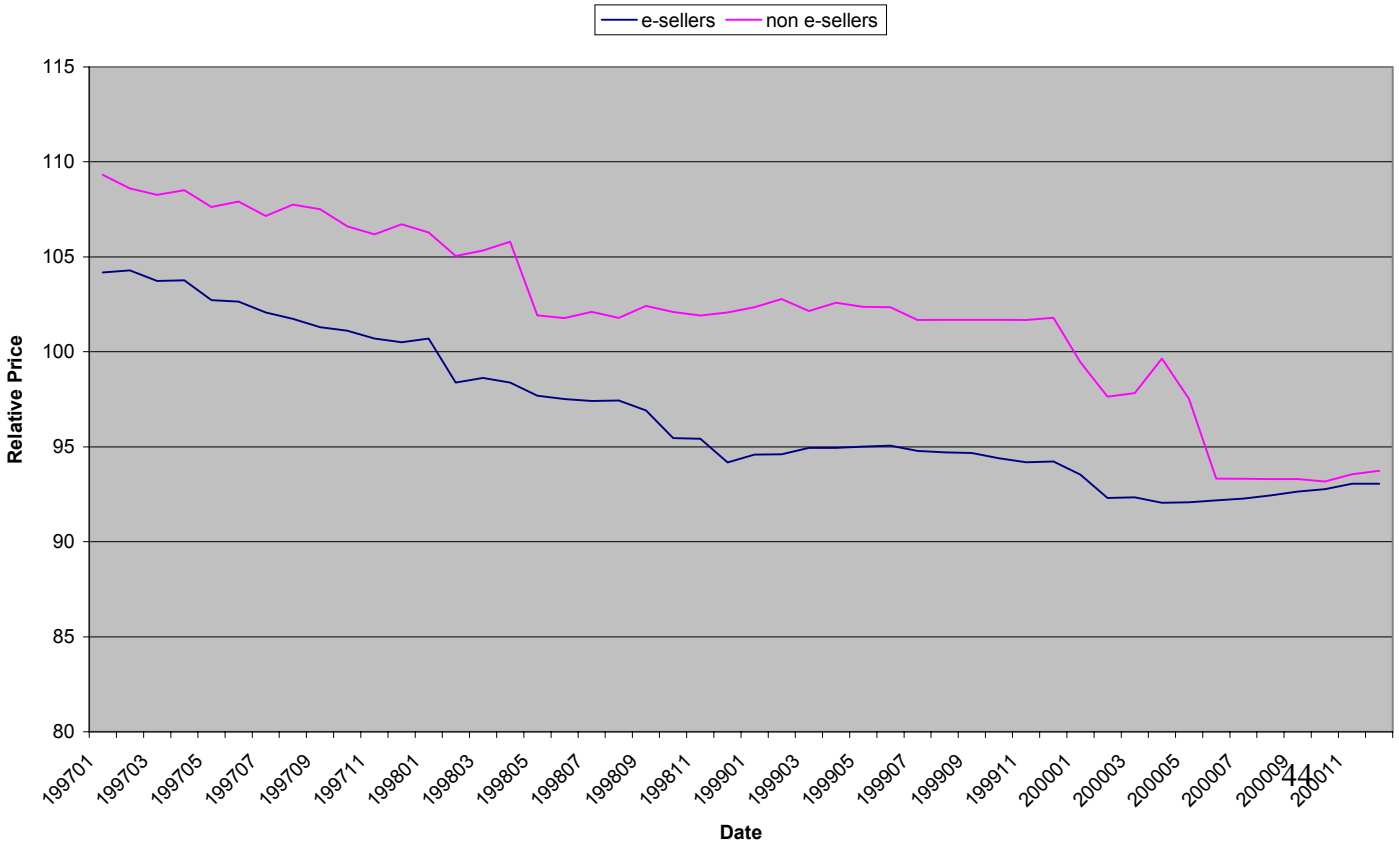
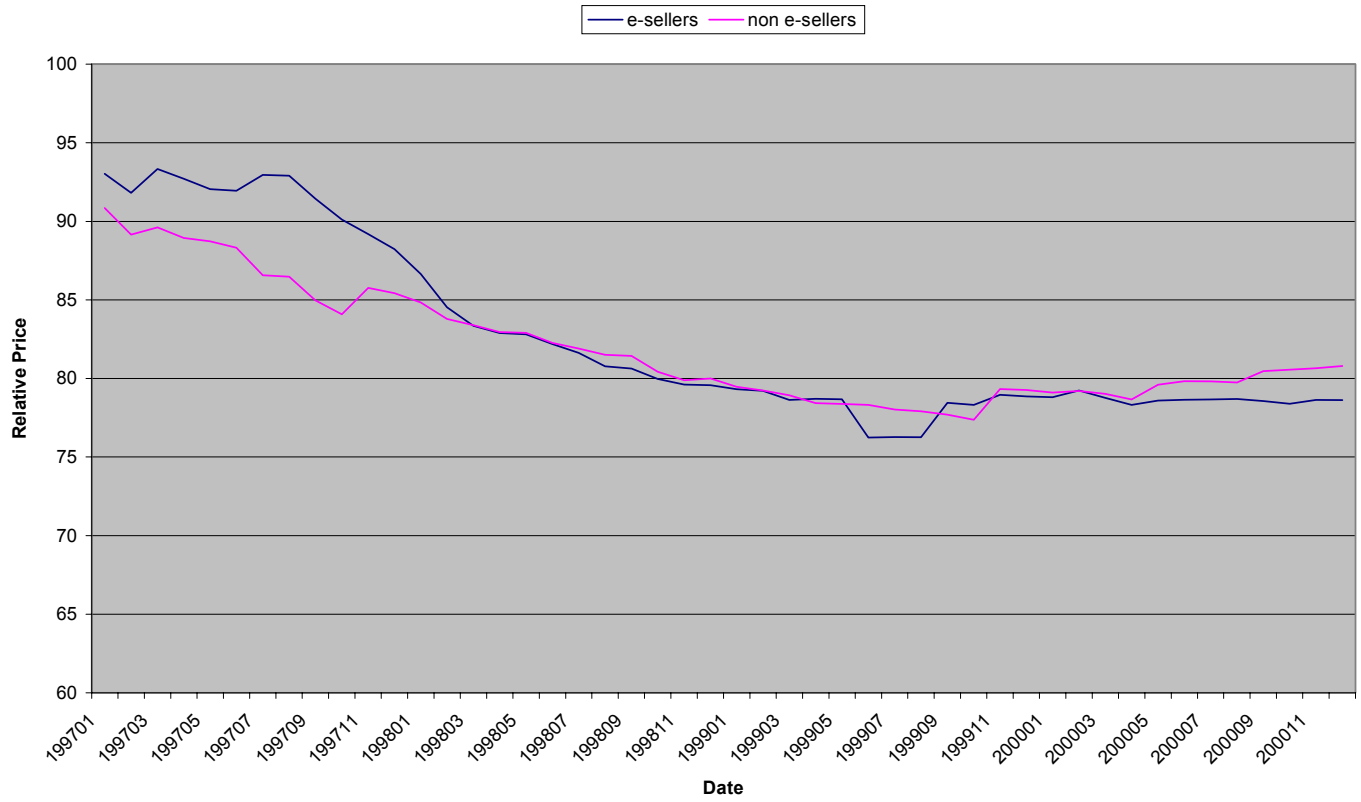


**Figure 7.4**
**3210 Manufacture of electronic valves and tubes and other electronic components**




**2212 Publishing of newspapers**

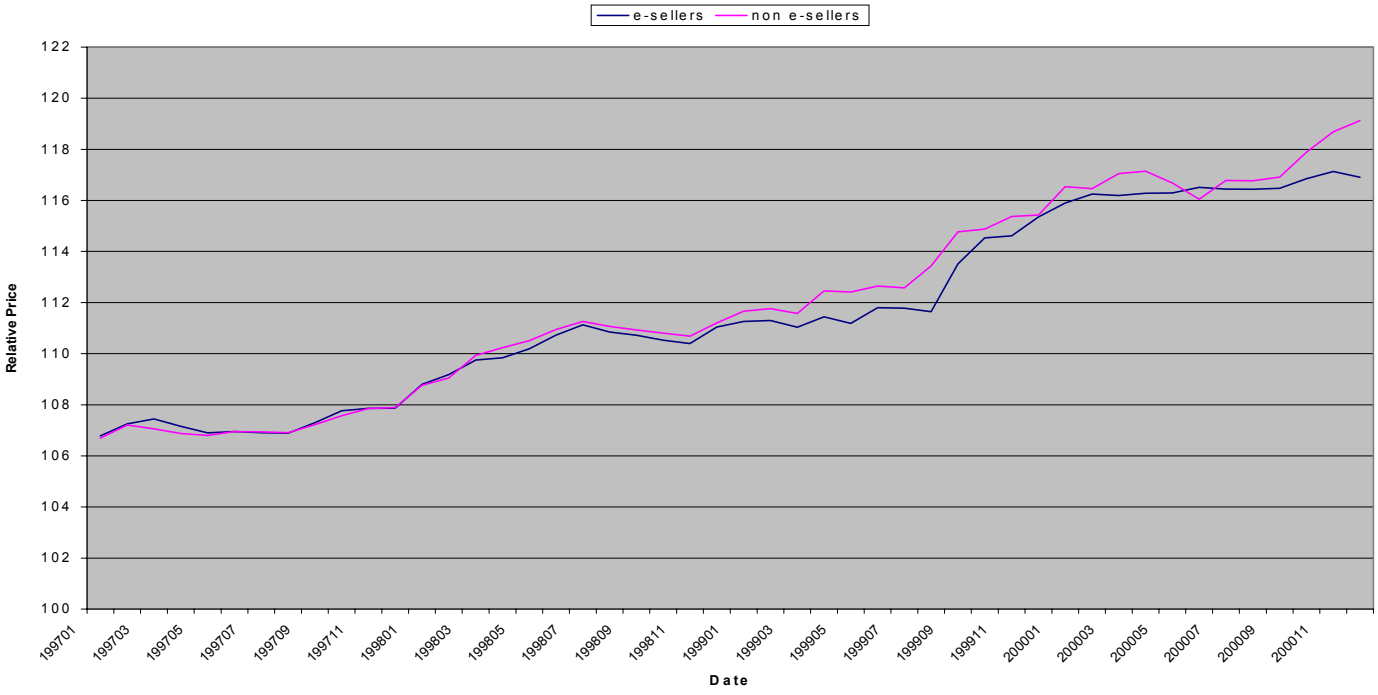
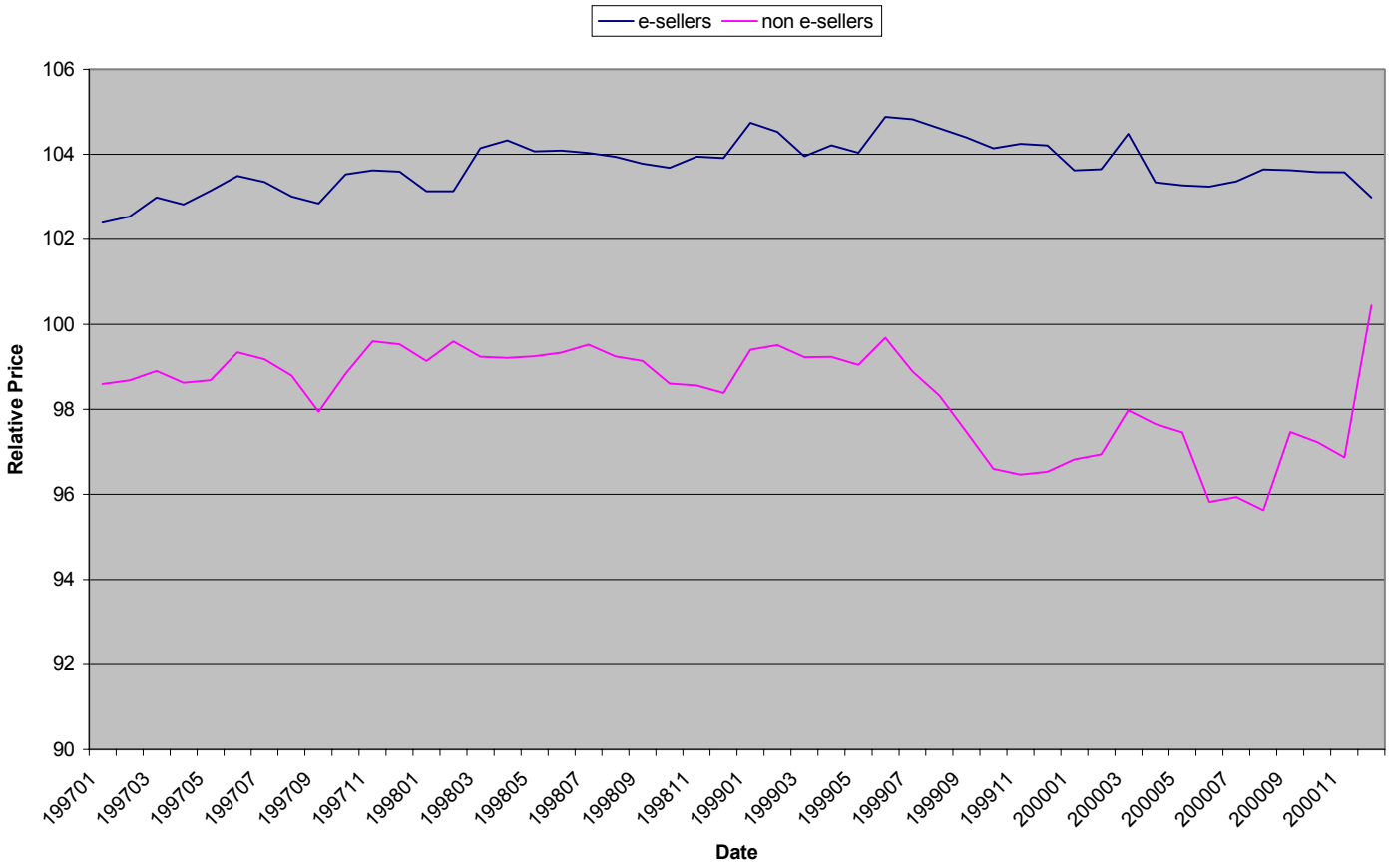


**Figure 7.5**

**24511 Manufacture of soap and detergents**




**3430 Manufacture of parts and accessories for motor vehicles and their engines**

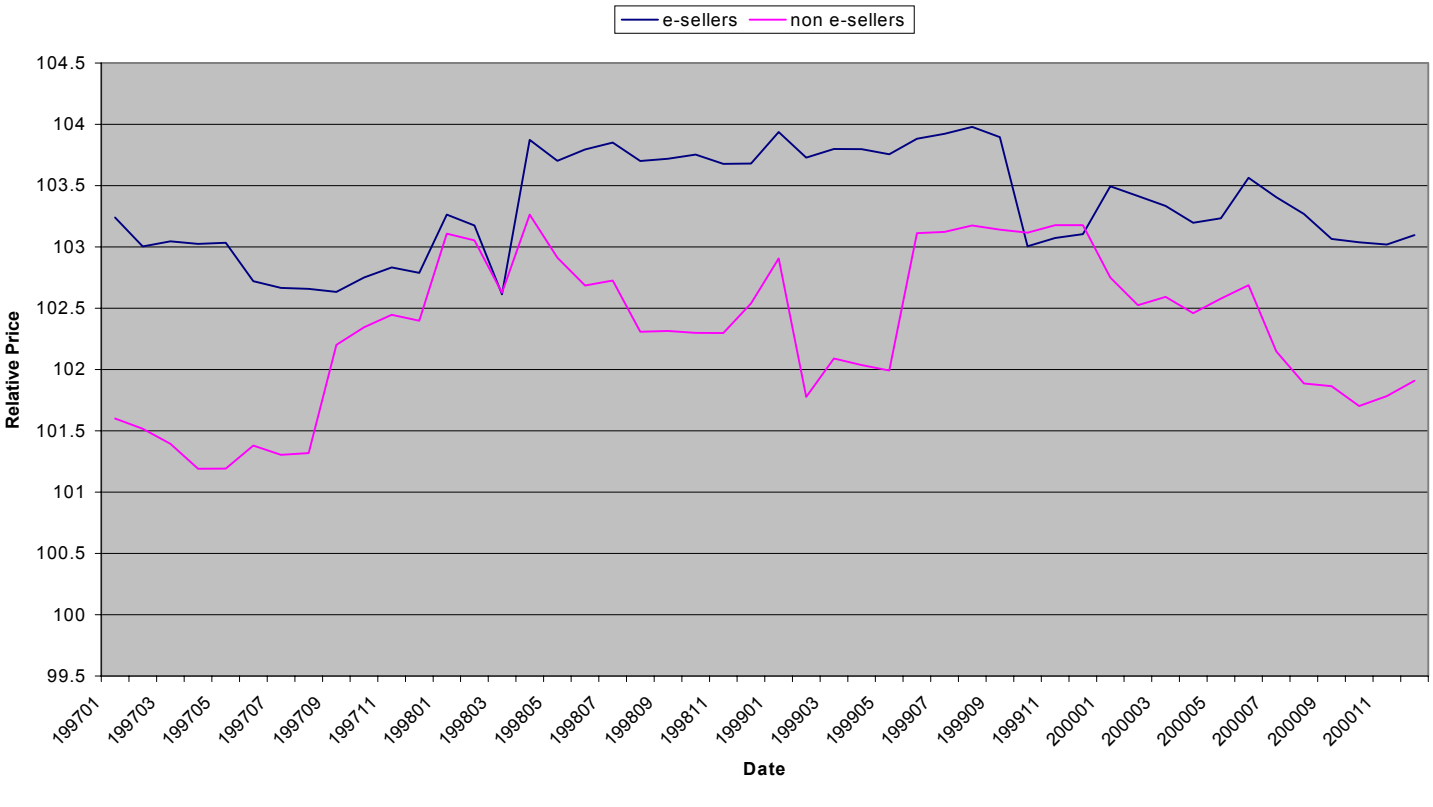
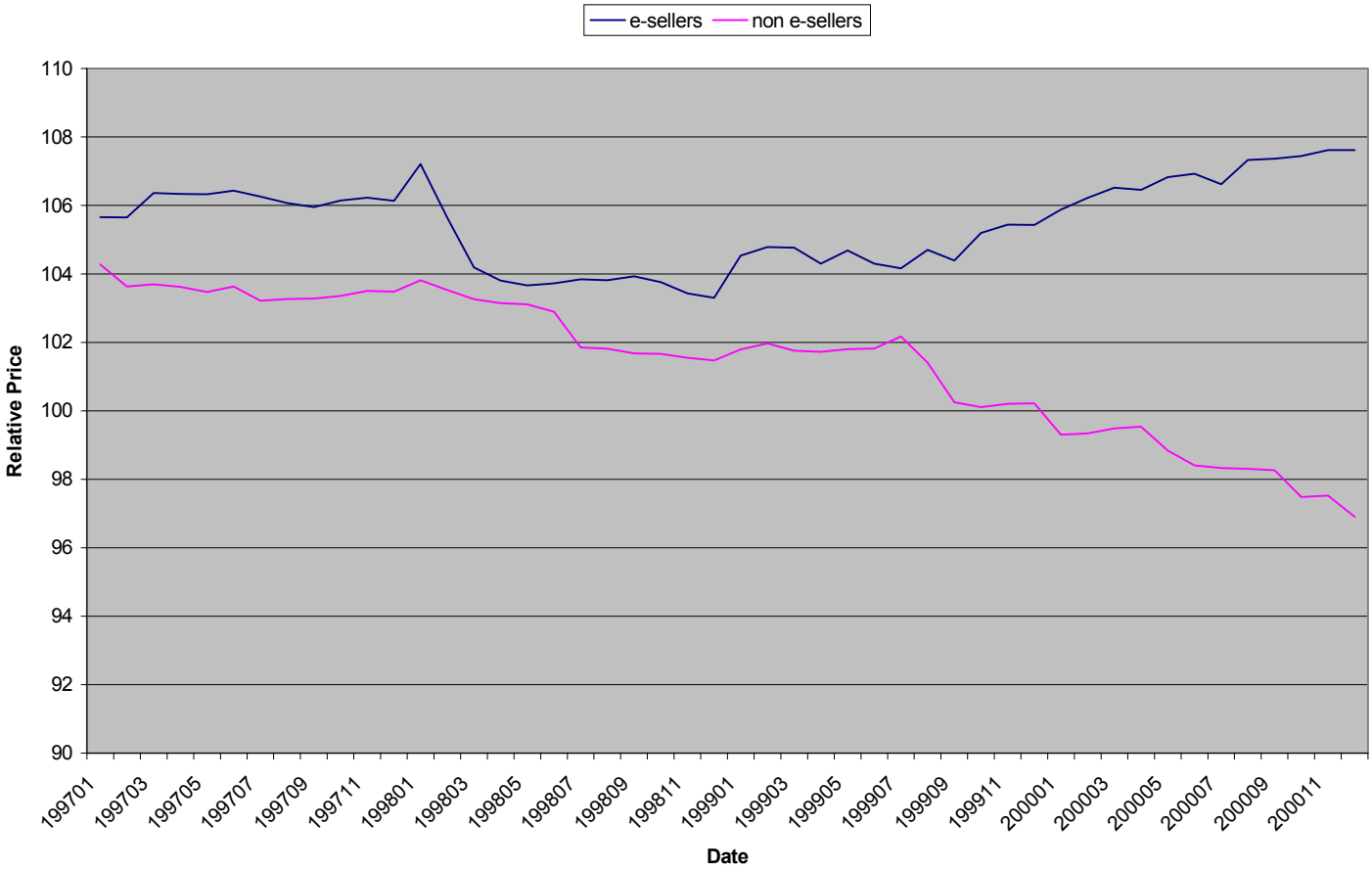


**Figure 7.6**

**2430 Manufacture of paints, varnishes and similar coatings, printing ink and mastics**



# 8 Service sector; retailing and stocks

## *8.1 Labour Productivity in Services*

The scope for extending the productivity and pricing analysis, contained in section 6 and 7 respectively, to the service sector is restricted. The first barrier is the absence of capital stock estimates at firm level. These are required to employ a TFP approach, there is also a lack of comprehensive price quotes, which have only started to be collected by ONS relatively recently. Therefore our analysis of e-commerce in the service sector is limited to associations between e-commerce activity, labour productivity and operational ratios.

A breakdown of labour productivity, measured as value-added per employee, by two digit SIC code is shown in Figure 8.1 The methodology employed to generate the data is different from that used in section 6, partly because there is no PPI data to adjust value-added per employee). Three service sectors have been omitted, one due to disclosure issues and two for lack of analytical relevance.

It presents a very different and more varied picture of e-commerce impact from that for manufacturing. In eight of seventeen sectors e-sellers enjoy the highest levels of value-added per employee, suggesting either price advantages or real productivity gains. Price advantages may arise since e-commerce allows firms to increase value-added through provision of a differentiated service, or to deliver straight to the consumer, removing an element in the supply chain, as discussed in section 6. One example of this would be digital receipt of IT services (SIC 72) rather than trading in physical form.

However in five sectors it is firms that buy electronically that are the most productive, including Wholesale (SIC 51), Water / Air Transport (SIC 61 & 62) and Rental (SIC 71). This may be due to price competition effects since these are relatively price sensitive and commoditised sectors.

Of the remaining sectors five show higher labour productivity for firms that do not conduct purchases or sales via e-commerce. One of these sectors is "Post and Telecommunications," an information service for which there are apparently no productivity gains associated with e-commerce activity; a surprising and unexpected result. However using e-commerce to buy is generally associated with higher labour productivity than not using e-commerce at all across most service sectors.

It is quite possible that many service firms trading electronically are engaged in different types of activities from those that do not, due to the inherent heterogeneity of services. To start comparative analysis of e-commerce effects in services, we have therefore chosen retailing which has relatively simplicity value chains, and comparable customer / supplier relationships and technology. Also, since retail has been a strong and effective user of e-commerce for some time, mainly in the form of EDI (Electronic Data Interchange), the effects of e-commerce may be more established in this sector.

## *8.2 Retail productivity*

The following analysis uses simple descriptive data, produced using the ARD (Annual Respondents Database) which is the longitudinal series of ABI surveys, to examine productivity trends in the retail sector over time, between different sub-sectors and according to e-commerce

activity. The analysis only included firms that have at least ten employees, positive values reported for value-added, and value-added to sales ratios of less than one hundred.

The majority of firms in the retail sector fall under the following headings:

- Retail sale in specialised stores which includes confectioners' tobacconists and newsagents (SIC52.1)
- Retail sale of food, beverages and tobacco in specialised stores (SIC52.2)
- Retail sale of pharmaceutical and medical goods, cosmetic and toilet articles (SIC52.3)
- Other retail sale of new goods in specialised stores (SIC52.4) (which mainly comprises of firms selling comparison goods)

Tables 8.1 to 8.4 show labour productivity values in the four main sub-sectors of retail between 1997 and 2001. Figures provided in parentheses refer to the number of observations, "Emp" refers to employment, "VA/emp" to value-added per employee and "GO/emp" to gross output per employee. All other cells are averages generated by weighting all responses equally. It can be seen that there is a clear upward trend, with some volatility, in value added per employee in all of the main sub-sectors of retail, but particularly in SIC52.1 and SIC52.4.

Comparing against price changes shows that there have been real gains in labour productivity in all four sectors over this period. Gross output per employee has also grown in all sectors except SIC52.2. (note that there are differences in the methodology to generate value-added in the following analysis to that employed in Figure 8.1, and that gross output is total turnover).

**Table 8.1: SIC 52.1 Retail sale in non-specialised stores**

| Year | 1997 | 1998 | 1999 | 2000 | 2001 |
|---|---|---|---|---|---|
| | 52.1 (296) | 52.1 (318) | 52.1 (290) | 52.1 (293) | 52.1 (334) |
| Emp | 3178.15 | 2369.14 | 2378.96 | 3464.04 | 3256.18 |
| VA/emp | 15.394 | 15.869 | 16.451 | 18.932 | 19.832 |
| GO/emp | 59.220 | 65.567 | 65.513 | 65.525 | 76.873 |

**Table 8.2: SIC 52.2 Retail sale of food, beverages and tobacco in specialised stores**

| Year | 1997 | 1998 | 1999 | 2000 | 2001 |
|---|---|---|---|---|---|
| | 52.2 (231) | 52.2 (227) | 52.2 (274) | 52.2 (249) | 52.2 (285) |
| Emp | 258.52 | 115.98 | 207.36 | 211.49 | 203.11 |
| VA/emp | 13.979 | 15.185 | 13.667 | 14.653 | 16.679 |
| GO/emp | 53.610 | 48.578 | 46.199 | 52.274 | 51.139 |

**Table 8.3: SIC 52.3 Retail sale of pharmaceutical and medical goods, cosmetic and toilet articles**

| Year | 1997 | 1998 | 1999 | 2000 | 2001 |
|---|---|---|---|---|---|
| | 52.3 (175) | 52.3 (164) | 52.3 (139) | 52.3 (145) | 52.3 (154) |
| Emp | 202.51 | 267.32 | 173.09 | 305.49 | 320.17 |
| VA/emp | 18.655 | 19.305 | 20.338 | 23.186 | 22.408 |
| GO/emp | 77.257 | 75.899 | 85.351 | 98.110 | 93.415 |

**Table 8.4: SIC 52.4 Other retail sale of new goods in specialised stores**

| Year | 1997 | 1998 | 1999 | 2000 | 2001 |
|---|---|---|---|---|---|
| | 52.4 (1161) | 52.4 (1009) | 52.4 (1005) | 52.3 (1033) | 52.3 (1145) |
| **Emp** | 443.01 | 309.01 | 386.32 | 566.29 | 555.74 |
| **VA/emp** | 22.733 | 24.585 | 33.660 | 26.021 | 29.368 |
| **GO/emp** | 67.314 | 69.952 | 91.317 | 70.443 | 80.550 |

Tables 8.5 to 8.8 (see annex) split the data by firm size, with the break point at hundred employees, as well as by sector, and suggest that labour productivity has risen in both larger and smaller firms, but has been most marked among the smaller.

The next strand of analysis explores the effects of e-commerce on the retail sector as a whole, and results are shown in Tables 8.8 and 8.10. Unlike manufacturing, the data suggests that e-selling is positively associated with labour productivity (as in Figure 8.1), as is using e-commerce to both place and receive orders. It seems retailers that sell electronically may be able to retain the productivity gain, and not pass it on in the form of lower prices, which is what appears to occur in manufacturing as shown in section 7. This is because retail consists mainly of business-to-consumer (B2C) activity, as opposed to business-to-business (B2B) activity, and consumers have less incentive to employ low search cost activities.

There is no evidence of a productivity gain for e-procurement in the 2000 data (below or in Figure 8.1), but there is in 2001, although it is not as large as that for firms that only sell electronically or those that do both. Therefore it appears that e-commerce enables retailers to improve the productivity of their employees by substituting capital for labour and improving the efficiency of their downstream supply chain.

**Table 8.9: SIC 52 (2000)**

| | Either | | Buy only | | Sell only | | Both | |
|---|---|---|---|---|---|---|---|---|
| **N=1889** | **Yes (541)** | **No (1348)** | **Yes (204)** | **No (1685)** | **Yes (137)** | **No (1752)** | **Yes (200)** | **No (1689)** |
| **Emp** | 2418.45 | 340.33 | 1982.00 | 808.80 | 967.16 | 933.02 | 3857.76 | 589.46 |
| **VA/emp** | 27.466 | 22.181 | 22.226 | 23.872 | 30.357 | 23.174 | 30.830 | 22.850 |
| **GO/emp** | 86.723 | 69.172 | 72.318 | 74.427 | 92.761 | 72.747 | 97.281 | 71.466 |

**Table 8.10: SIC 52 (2001)**

* Provisional data

| | Either | | Buy only | | Sell only | | Both | |
|---|---|---|---|---|---|---|---|---|
| **N=2103** | **Yes (691)** | **No (1412)** | **Yes (531)** | **No (1572)** | **Yes (160)** | **No (1943)** | **Yes (258)** | **No (1845)** |
| **Emp** | 2117.06 | 282.79 | 2407.85 | 371.26 | 1152.02 | 863.54 | 3154.74 | 568.16 |
| **VA/emp** | 29.709 | 24.288 | 28.140 | 25.370 | 34.917 | 25.341 | 32.042 | 25.234 |
| **GO/emp** | 91.141 | 72.618 | 85.123 | 76.536 | 111.114 | 76.036 | 92.189 | 76.819 |

When the 2000 data is split by scale as well as e-commerce activity, as in Table 8.11, it shows that using e-commerce solely for e-procurement is only associated with higher productivity in larger firms. The data also tentatively suggests that using e-commerce for selling is more beneficial for smaller firms than larger ones, whilst the opposite is true of those firms using it for both buying and selling. Using e-commerce

to either sell or trade in both directions also appears to generate substantially higher levels of gross output per employee.

**Table 8.11 Size (employment) and e-commerce**

| N=1889 | Either | <100 | Either | >=100 |
|---|---|---|---|---|
| | Yes (321) | No (1029) | Yes (220) | No (319) |
| Emp | 31.79 | 28.33 | 5900.79 | 1346.76 |
| VA/emp | 27.134 | 21.619 | 27.950 | 23.993 |
| GO/emp | 87.764 | 68.916 | 85.205 | 70.000 |
| | Buy only | <100 | Buy only | >=100 |
| | Yes (123) | No (1227) | Yes (81) | No (458) |
| Emp | 30.41 | 29.03 | 4945.53 | 2897.83 |
| VA/emp | 22.496 | 22.974 | 21.816 | 26.278 |
| GO/emp | 72.075 | 73.530 | 72.686 | 76.828 |
| | Sell only | <100 | Sell only | >=100 |
| | Yes (72) | No (1278) | Yes (65) | No (474) |
| Emp | 37.17 | 28.70 | 1997.31 | 3371.24 |
| VA/emp | 31.408 | 22.453 | 29.192 | 25.116 |
| GO/emp | 100.328 | 71.880 | 84.378 | 75.085 |
| | Both | <100 | Both | >=100 |
| | Yes (126) | No (1224) | Yes (74) | No (465) |
| Emp | 30.08 | 29.06 | 10375.15 | 2064.58 |
| VA/emp | 29.220 | 22.283 | 33.573 | 24.340 |
| GO/emp | 95.899 | 71.081 | 99.633 | 72.478 |

Further splitting of the 2000 data (Tables 8.12 to 8.15) suggests:

- the effect of electronic selling on labour productivity is evident in all sectors,
- the negative association with e-procurement is also evident in all sectors except SIC52.4
- the positive association with doing both is also evident in all sectors except SIC52.1 and appears remarkably strong in SIC52.3

It appears that e-sellers have a definite productivity advantage whilst e-buyers tend to suffer from lower levels of labour productivity, but there are no obvious reasons why.

The final set of data for 2000 has been split according to size, e-commerce activity and sector, and is presented in Tables 8.16 to 8.18 (except for categories which might be disclosive). Results presented show that there tends to be a productivity advantage for larger firms from e-commerce activity. Splitting the data also helps reveal further scale related sector-specific effects. For instance:

- in SIC52.1 larger e-procurers suffer from lower productivity
- in SIC52.2 larger firms benefit from using e-commerce to either place or receive orders
- in SIC52.4, although e-procurement is associated with lower productivity for larger firms, smaller firms show the opposite tendency
- in the case of firms that both buy and sell electronically it is clear that it is the larger firms gain most in SIC52.4. This is reasonable since the figures for average employment indicate that this sector may have most scope for economies of scale. It is also the sector most likely to contain firms with the resources and market scale to benefit from integration of processes within their supply chain.

The data for 2001 is not presented since it is provisional but it suggests that e-procurement may result in productivity gains, especially for smaller firms. In terms of e-sellers it is again the smaller firms that experience the greatest productivity gain, supporting the findings for 2000. The labour productivity value for those firms that both bought and sold electronically in SIC52.3 shows some differences from the 2000 pattern, although there still a clear productivity gain for e-sellers in this sector.

Further splits taking scale into consideration show that:

- in SIC52.1 there is only a productivity gain for the smaller e-buyers, whereas any gain for those that do both only occurs in larger firms, which is acceptable for reasons discussed previously
- in SIC52.2 it is again the smaller e-procurers that enjoy higher productivity, whilst there is no such association for the larger firms
- in SIC52.4 it is the smaller firms that benefit the most from e-commerce activity, as they did in the 2000 data for all categories except "both"
- the larger firms in this sector that trade electronically also experience higher productivity, which was not the case in 2000 data

### *8.3 Retail Stocks*

Logistics, and more broadly supply chain management, are among the primary and most widely used applications of ICT. Theoretically ICT and e-commerce should allow firms to integrate, and even remove, areas in the B2B part of their supply chain. This concept can be easily understood in the context of the retail sector where, with the correct technology, product information can be "read" at the electronic point of sale (EpoS) and transmitted up the supply chain, thus automatically controlling stock levels.

One example of such a system is ECR (Efficient Customer Response) which auto-manages stock and replenishment between production and eventual sale. ICT allows retailers to become exponents of "pull logistics" and reduces risks of excess inventories by integrating their business processes. Increased concentration in the retail sector over the last decade may also mean that such practices are more evident since the scale of its major players may help them to force suppliers to hold stock further up the supply chain.

The following data is presented in exactly the same format to that on labour productivity in the retail sector above, but shows stock ratios for the period 1997-2001, to sales, value added and employment. Much of the discussion that follows focuses on stocks / sales.

**Table 8.19: SIC 52.1 Retail sale in non-specialised stores**

| **Year** | **1997** | **1998** | **1999** | **2000** | **2001** |
|---|---|---|---|---|---|
| **N firms** | **(296)** | **(318)** | **(290)** | **(293)** | **(334)** |
| **Emp** | 3178.15 | 2369.14 | 2378.96 | 3464.04 | 3256.18 |
| **Stock/Sales** | 0.0877 | 0.0770 | 0.0839 | 0.0794 | 0.0736 |
| **Stock/VA** | 0.3473 | 0.4391 | 0.3627 | 0.3381 | 0.2929 |
| **Stocks/Emp** | 5.0764 | 4.6827 | 5.2144 | 4.9779 | 5.0113 |

There is some evidence in tables 8.19 to 8.22 of a decline in stock/sales ratios since 1997, although the time series is short. The stock/sales ratios in all sectors has fallen by 2001, which means that in operational terms rates of retail stock turn have risen.

Since stocks are a key part of retailing capital, this decline represents an efficiency gain. However, the ratio of most concern to retailers is stock / value added since this captures both operational and economic effects. For example, if lower stocks means less choice offered by retailers, consumers may only be prepared to pay lower prices, which would affect 'real' productivity. Stock / value added ratios, although more volatile, have also shown a downward trend since 1997.

**Table 8.20: SIC 52.2 Retail sale of food, beverages and tobacco in specialised stores**

| Year | 1997 | 1998 | 1999 | 2000 | 2001 |
|---|---|---|---|---|---|
| N firms | (231) | (227) | (274) | (249) | (285) |
| Emp | 258.52 | 115.98 | 207.36 | 211.49 | 203.11 |
| Stock/Sales | 0.0330 | 0.0316 | 0.0297 | 0.0338 | 0.0298 |
| Stock/VA | 0.1579 | 0.1375 | 0.1386 | 0.1422 | 0.1061 |
| Stocks/Emp | 2.2418 | 1.8795 | 1.8488 | 2.2112 | 1.9695 |

Results for retail sector 52.2 are harder to gauge. It appears that there may have been a slight decline in stocks but less than in the other three main sectors of retail. Also, whilst the decline in stock/sales is not so evident, it is again supported by the other two stock ratios, as is the temporary rise in 2000.

**Table 8.21: SIC 52.3 Retail sale of pharmaceutical and medical goods, cosmetic and toilet articles**

| Year | 1997 | 1998 | 1999 | 2000 | 2001 |
|---|---|---|---|---|---|
| N firms | (175) | (164) | (139) | (145) | (154) |
| Emp | 202.51 | 267.32 | 173.09 | 305.49 | 320.17 |
| Stock/Sales | 0.0928 | 0.0919 | 0.0932 | 0.0858 | 0.0767 |
| Stock/VA | 0.4432 | 0.4479 | 0.5033 | 0.5971 | 0.3702 |
| Stocks/Emp | 7.0340 | 6.8284 | 7.6076 | 9.2103 | 6.8217 |

Decline in stocks is much more evident in SIC52.3 not only in terms of stock/sales but also stock/value-added, although stocks per employee are volatile. This area of retailing has smaller firms, as indicated by average employment, so volatility in the employment ratio may reflect variation in the sample selected. A similar statistical effect may be present in the data for SIC 52.4.

**Table 8.22: SIC 52.4 Other retail sale of new goods in specialised stores**

| Year | 1997 | 1998 | 1999 | 2000 | 2001 |
|---|---|---|---|---|---|
| N firms | (1161) | (1009) | (1005) | (1033) | (1145) |
| Emp | 443.01 | 309.01 | 386.32 | 566.29 | 555.74 |
| Stock/Sales | 0.1582 | 0.1524 | 0.155 | 0.1476 | 0.1417 |
| Stock/VA | 0.7409 | 0.503 | 0.5982 | 0.5431 | 0.5948 |
| Stocks/Emp | 10.341 | 9.972 | 11.319 | 9.8412 | 11.173 |

.

The importance of size is borne out by analysis splitting the data according to firm size, as in Tables 8.23 to 8.26. This reveals that it is the smaller firms that have experienced falling stocks whilst the larger firms have maintained fairly constant ratios in all sectors except SIC52.2 where the opposite is true. This suggests that scale effects vary from sector to sector. It also appears that larger firms tend to hold more stock relative to sales in all sectors except SIC52.4.

One hypothesis to explain the downward trend in stocks over time is that it is due to the increasing use of electronic networks. Therefore the information on whether or not firms use e-commerce to place/receive orders, collected using the ABI (Annual Business Inquiry) in 2000 and 2001, was used to test whether there is any association between e-commerce and lower inventory levels.

The results, shown in Tables 8.27 and 8.28, are broadly consistent between years but with some variation. For instance, in 2000 firms that use e-commerce to only place orders appear to hold lower stocks, but this is not evident in the 2001 data in terms of the stock/sales ratio. The data shows little or no effect for those firms that use e-commerce for either placing or receiving orders, or indeed both, thus not confirming the anticipated effects, at least when considering the retail sector as a whole. However, firms that use e-commerce to only receive orders hold more stock, which at first is a little surprising but possible reasons are explored below. It appears that e-commerce effects attributable to buying and to selling may cancel each other out in the "either" and "both" categories below.

**Table 8.27: SIC 52 Retail (2000)**

| | **Either** | | **Buy only** | | **Sell only** | | **Both** | |
|---|---|---|---|---|---|---|---|---|
| **N=1889** | **Yes (541)** | **No (1348)** | **Yes (204)** | **No (1685)** | **Yes (137)** | **No (1752)** | **Yes (200)** | **No (1689)** |
| **Emp** | 2418.45 | 340.33 | 1982.00 | 808.80 | 967.16 | 933.02 | 3857.76 | 589.46 |
| **Stock/Sales** | 0.1169 | 0.1116 | 0.0991 | 0.1148 | 0.1463 | 0.1106 | 0.1148 | 0.1129 |
| **Stock/VA** | 0.3962 | 0.4835 | 0.3576 | 0.4707 | 0.4599 | 0.4584 | 0.3920 | 0.4663 |
| **Stocks/Emp** | 9.8597 | 8.1056 | 6.8246 | 8.8239 | 12.9827 | 8.2659 | 10.8164 | 8.3465 |

**Table 8.28: SIC 52 Retail (2001)**
** Provisional data*

| | **Either** | | **Buy only** | | **Sell only** | | **Both** | |
|---|---|---|---|---|---|---|---|---|
| | **Yes (691)** | **No (1412)** | **Yes (531)** | **No (1572)** | **Yes (160)** | **No (1943)** | **Yes (258)** | **No (1845)** |
| **Emp** | 2117.06 | 282.79 | 2407.85 | 371.26 | 1152.02 | 863.54 | 3154.74 | 568.16 |
| **Stock/Sales** | 0.1159 | 0.1041 | 0.1092 | 0.1076 | 0.1380 | 0.1055 | 0.1198 | 0.1064 |
| **Stock/VA** | 0.4273 | 0.4926 | 0.3917 | 0.4980 | 0.5455 | 0.4651 | 0.3751 | 0.4846 |
| **Stocks/Emp** | 11.5044 | 8.4810 | 8.6739 | 9.7448 | 20.8979 | 8.5338 | 10.2655 | 9.3638 |

It may be that e-selling firms hold greater stocks due to increased variety and unpredictable sales patterns, since e-commerce can be used to offer greater customer choice. Against this stands the argument that since the order is electronic, the retailer does not need to hold the product in the form of stock since the information can be processed and delivery organised directly from the supplier. However, this will only be the case if firms have the electronic networks to place orders and will also depend on the relative levels of market influence of the retailer and their supplier(s). E-selling firms may order in bulk and hold more stock in anticipation of greater sales; the data supports this picture.

Since the above analysis provides no evidence of statistical significance, regression analysis, using stock/sales as the dependent variable and including dummies to reflect the nature of e-commerce activity undertaken by firms and their sector within retail, was conducted and supports this data. An employment variable to capture any scale effects was also included. The results for the linear specification show significant coefficients in the direction shown in the descriptive data for e-procurement and e-selling. The results are shown in Appendix A.

The next analysis considers whether the effects described above applied consistently across large and small firms. Therefore the firms were also split according to scale and, as can be seen in Table 8.29, the negative association between e-procurement and stock is stronger for larger firms, whilst the positive association between electronic sales and stocks is stronger for smaller firms. The latter is intuitive since it is the larger firms who will have the supplier relationships to ensure stock remains further up the supply chain.

**Table 8.29**

| **2000** | **Either** | **<100** | **Either** | **>=100** |
|---|---|---|---|---|
| | **Yes (321)** | **No (1029)** | **Yes (220)** | **No (319)** |
| **Emp** | 31.79 | 28.33 | 5900.79 | 1346.76 |
| **Stock/Sales** | 0.122 | 0.113 | 0.109 | 0.107 |
| **Stock/VA** | 0.425 | 0.517 | 0.354 | 0.374 |
| **Stocks/Emp** | 10.68 | 8.181 | 8.663 | 7.863 |
| **2000** | **Buy only** | **<100** | **Buy only** | **>=100** |
| | **Yes (123)** | **No (1227)** | **Yes (81)** | **No (458)** |
| **Emp** | 30.41 | 29.03 | 4945.53 | 2897.83 |
| **Stock/Sales** | 0.104 | 0.116 | 0.091 | 0.11 |
| **Stock/VA** | 0.388 | 0.506 | 0.311 | 0.376 |
| **Stocks/Emp** | 7.393 | 8.914 | 5.962 | 8.583 |
| **2000** | **Sell only** | **<100** | **Sell only** | **>=100** |
| | **Yes (72)** | **No (1278)** | **Yes (65)** | **No (474)** |
| **Emp** | 37.17 | 28.7 | 1997.31 | 3371.24 |
| **Stock/Sales** | 0.164 | 0.113 | 0.126 | 0.105 |
| **Stock/VA** | 0.527 | 0.494 | 0.386 | 0.364 |
| **Stocks/Emp** | 15.586 | 8.391 | 10.099 | 7.927 |
| **2000** | **Both** | **<100** | **Both** | **>=100** |
| | **Yes (126)** | **No (1224)** | **Yes (74)** | **No (465)** |
| **Emp** | 30.08 | 29.06 | 10375.15 | 2064.58 |
| **Stock/Sales** | 0.116 | 0.115 | 0.113 | 0.107 |
| **Stock/VA** | 0.402 | 0.505 | 0.375 | 0.365 |
| **Stocks/Emp** | 11.086 | 8.537 | 10.357 | 7.844 |

For the retail sector as a whole it appears that using e-commerce to place orders is negatively associated with stocks for larger firms. However, e-selling appears to require higher stocks, particularly for smaller firms. The effects are not exactly the same for each of the four main sectors in retail, as can be seen below in Tables 8.30 to 8.33. For instance, in SIC52.1, SIC52.3 and SIC52.4, stores that use e-commerce to both place and receive orders hold less stock, suggesting benefits from integration of business processes. Data for those that use e-commerce only to sell is only available in SIC52.1 and SIC52.4, due to unsuitable sample sizes. However in each case they hold more stock than their counterparts that do not sell electronically. Firms that use e-commerce solely for e-procurement hold higher stocks in all sectors except SIC52.1.

It has only been possible to split the data on three dimensions at once, according to e-commerce activity, SIC code and scale, in cases where the sample size allows.

The results, presented in Tables 8.34 and 8.35, suggest:

- in SIC52.1 the e-procurement gain applies only to larger firms and may be partially hidden in the more aggregated data since smaller firms tend to experience the opposite effect
- it is the larger e-sellers that hold higher stocks

- it is the smaller firms that benefit most from conducting both purchases and sales via e-commerce
- there is an e-procurement effect for smaller firms in SIC52.3 of a similar magnitude to that for the sector as a whole
- in SIC52.4 it is the smaller firms that benefit most from e-procurement and doing "both" in the form of lower stocks
- the now expected positive association with e-selling only applies to smaller firms in SIC52.4. Again this is reasonable for reasons given previously but may be more applicable in this sector due to the nature of the products and the scale of some retailers in this sector.

In search of consistency between the two data sets the same analysis was conducted using the ARD 2001. Although descriptive data for 2001 has not been included, since it is provisional, the results for firms that use e-commerce to either place or receive orders, and those that use it to only receive orders, are very consistent with 2000, although the e-procurement effect for larger firms is not evident.

More specifically:
- firms that use e-commerce solely for sales hold higher stocks in all sectors except SIC52.4, thus broadly supporting the 2000 data
- however firms that use e-commerce solely for e-procurement only enjoy lower stocks in SIC 52.3, whereas this was also the case in SIC52.2 and SIC52.4 in 2000
- firms that both buy and sell electronically are only associated with lower stock holdings in SIC52.3, compared to SIC52.1, SIC52.3 and SIC52.4 in 2000
- the descriptive data for SIC52.1 and SIC52.2 in 2001 provides the perverse result that both buying and selling electronically is associated with higher stock, although it may be that these firms have identified this and trade electronically in an attempt to remove this problem.

However it should be noted that the 2001 data is also less reliable in the sense that it is provisional and hence, to some extent, incomplete.

The sample size did not allow for a complete split of the data according to sector, size and e-commerce activity. Those results that were satisfactory in terms of observations showed:
- an e-procurement effect for larger firms but not smaller firms in SIC52.1 and SIC52.2, thus supporting the 2000 data in the case of SIC52.1 (such data for SIC52.2 in 2000 could not be presented)
- neither large nor small firms in SIC52.4 appear to benefit from buying electronically, unlike in 2000 when smaller firms in this group held lower stocks
- the e-selling effect in SIC52.4 applying only to larger firms, thus contradicting the 2000 data when it applied only to smaller firms.

There is enough consistency between the two years to suggest these effects are real and vary according to scale and sector, as would be expected. However it should be noted that the descriptive data should not be read as conclusive evidence of determination since there may be an element of reverse causality (although in the case of e-buying this would mean the effect is understated in the descriptive data).

*8.4 Conclusions*

It appears that the using e-commerce only for procurement may have a negative impact on stocks, especially for larger firms. Using it to only receive orders appears to have the opposite effect.

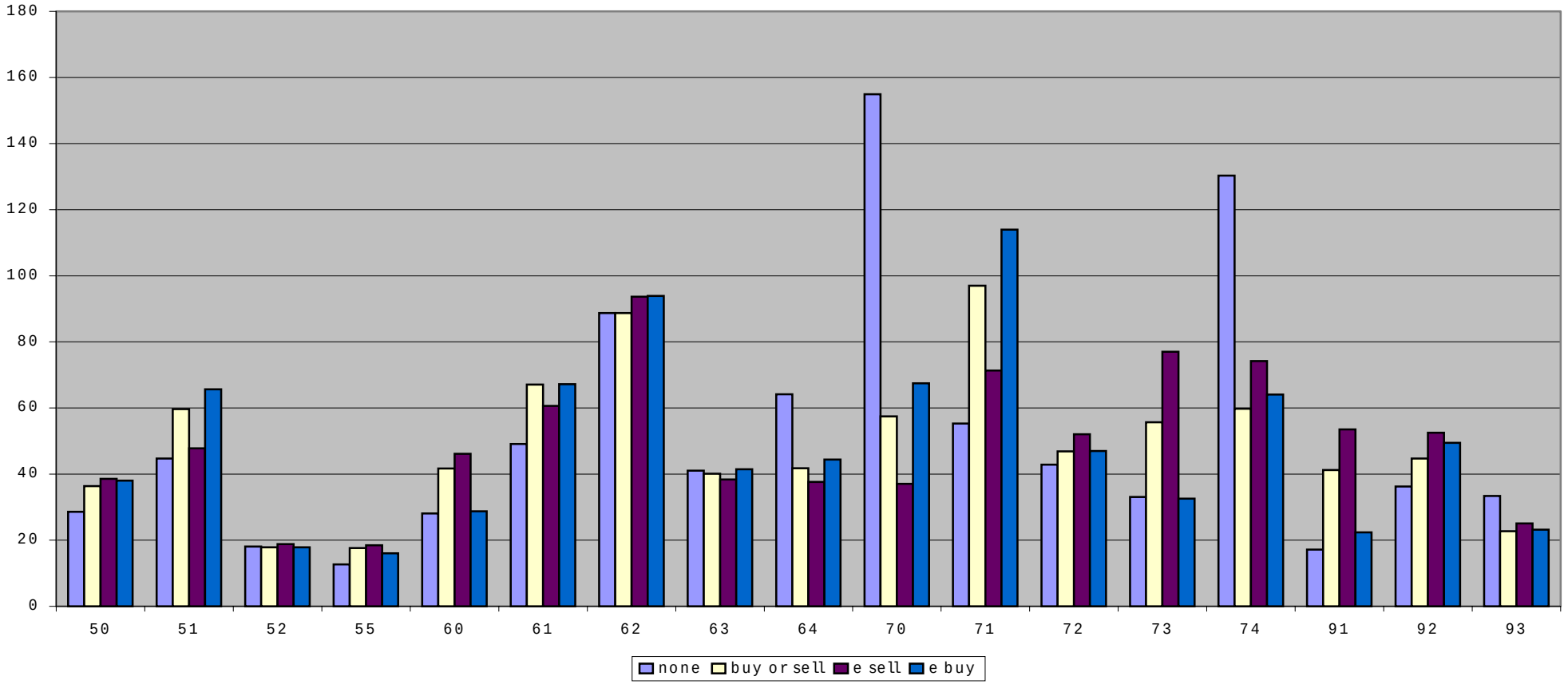
In terms of labour productivity the clearest association is with receiving orders electronically but firms that use it for both also tend to experience higher levels of labour productivity. However, the effects vary across sectors

The varied pattern of productivity advantage in e-procurement in retail may reflect different systems and standards within the sector and also the different implications for prices in B2C markets compared to B2B markets.

Other studies (PWC 2000) suggest that retailers, particularly smaller ones, may not be fully utilising the capabilities of e-commerce as they are concerned that it may provide larger manufacturers with the means to discriminate in terms of what they supply and at what price. The same source also provides evidence that only 28% of retailers perceived a positive impact of e-procurement, compared to 52% that held positive expectations. Therefore, despite the extent of use of e-commerce in the retail sector it may take time to realise benefits due difficulties in changing relationships, and inertia in the supply chain.

**Figure 8.1**

**Value Added/employee 2000: Services**



## Appendix A

*Regression Analysis*

As can be seen below the results suggest that scale does have a negative effect but is not significant. However since larger firms are more likely to use e-commerce and be classified in SIC52.4, then it may be that the dummies are removing part of the scale effect. More encouraging are the significant coefficients for two of the e-commerce dummies in the direction suggested in the descriptive data since the dummy for only buying electronically is negative and significant at the 10% level, whilst that for e-selling has a positive coefficient significant at 1%. Using e-commerce for both does generate a negative coefficient but it is not significant. The results also show that sector is a very important determinant of stocks with a significant positive coefficient for SIC52.4 and a significant negative coefficient for SIC52.2, reflecting the different purchase frequencies of food and comparison goods.

| | (1) | (2) |
|---|---|---|
| Dependent variable: | stock/sales | log (stock/sales) |
| employment | -3.25E-07 | |
| | (0.28) | |
| log (employment) | | 0.025593 |
| | | (0.028)** |
| ebuy only | -0.01105 | -0.043644 |
| | (0.097)* | (0.507) |
| esell only | 0.031157 | 0.328346 |
| | (0)*** | (0)*** |
| Both | -0.00402 | 0.048985 |
| | (0.553) | (0.461) |
| dummy 52.1 | -0.01151 | 0.115725 |
| | (0.181) | (0.177) |
| dummy 52.2 | -0.05676 | -0.935274 |
| | (0)*** | (0)*** |
| dummy 52.3 | -0.00521 | 0.386424 |
| | (0.603) | (0)*** |
| dummy 52.4 | 0.051632 | 0.710197 |
| | (0)*** | (0)*** |
| intercept | 0.091761 | -3.039248 |
| | (0)*** | (0)*** |
| Adjusted R-squared | 0.1757 | 0.3036 |
| Observations | 1907 | 1874 |

*** Significant at 1% level
** Significant at 5% level
* Significant at 10% level

Since that these relationships may not be linear the model has also been run under a logged specification. This improves the fit of the model with the adjusted R-squared rising to 0.3. However there is a positive and significant coefficient for employment, which is difficult to explain from a theoretical point of view, but is supported by the descriptive data in 2000 for all sectors except SIC52.4. Although economies of scale were anticipated they may be may not be a reality in all sectors of retail. The implications of the rest of the coefficients are broadly similar to the linear model but stronger due to the greater significance of the other sector dummies. Both regressions broadly support the previous analysis and suggest that e-commerce activity is associated with clear patterns in stock levels.

## ANNEX 8

### Size and sector - productivity

### Table 8.5: SIC 52.1 Retail sale in non-specialised stores

| 52.1 | 1997 | 1998 | 1999 | 2000 | 2001 |
|---|---|---|---|---|---|
| **<100** | **(147)** | **(189)** | **(154)** | **(159)** | **(195)** |
| **Emp** | 29.18 | 28.44 | 29.98 | 31.31 | 31.63 |
| **VA/emp** | 12.881 | 13.191 | 13.362 | 13.501 | 19.023 |
| **GO/emp** | 49.617 | 59.345 | 54.834 | 56.254 | 78.091 |
| **>=100** | **(149)** | **(129)** | **(136)** | **(134)** | **(139)** |
| **Emp** | 6284.85 | 5798.53 | 5038.83 | 7537.19 | 7779.83 |
| **VA/emp** | 17.874 | 19.794 | 19.949 | 25.376 | 20.968 |
| **GO/emp** | 68.695 | 74.684 | 77.605 | 76.526 | 75.165 |

### Table 8.6: SIC 52.2 Retail sale of food, beverages and tobacco in specialised stores

| 52.2 | 1997 | 1998 | 1999 | 2000 | 2001 |
|---|---|---|---|---|---|
| **<100** | **(184)** | **(232)** | **(216)** | **(197)** | **(232)** |
| **Emp** | 24.90 | 29.63 | 26.46 | 25.75 | 26.13 |
| **VA/emp** | 14.072 | 15.331 | 13.471 | 14.207 | 16.882 |
| **GO/emp** | 53.983 | 48.026 | 46.476 | 52.485 | 51.756 |
| **>=100** | **(47)** | **(45)** | **(58)** | **(52)** | **(53)** |
| **Emp** | 1173.11 | 561.18 | 881.09 | 915.15 | 977.81 |
| **VA/emp** | 13.618 | 14.433 | 14.394 | 16.342 | 15.792 |
| **GO/emp** | 52.147 | 51.428 | 45.170 | 51.474 | 48.437 |

### Table 8.7: SIC 52.3 Retail sale of pharmaceutical and medical goods, cosmetic and toilet articles

| 52.3 | 1997 | 1998 | 1999 | 2000 | 2001 |
|---|---|---|---|---|---|
| **<100** | **(143)** | **(141)** | **(114)** | **(123)** | **(132)** |
| **Emp** | 32.13 | 27.00 | 25.28 | 28.25 | 29.31 |
| **VA/emp** | 18.910 | 19.600 | 20.349 | 24.103 | 22.779 |
| **GO/emp** | 79.130 | 77.457 | 88.126 | 101.254 | 93.604 |
| **>=100** | **(32)** | **(23)** | **(25)** | **(22)** | **(22)** |
| **Emp** | 963.94 | 1740.57 | 847.12 | 1855.50 | 2065.32 |
| **VA/emp** | 17.515 | 17.501 | 20.286 | 18.060 | 20.187 |
| **GO/emp** | 68.891 | 66.350 | 72.698 | 80.531 | 92.283 |

### Table 8.8: SIC 52.4 Other retail sale of new goods in specialised stores

| 52.4 | 1997 | 1998 | 1999 | 2000 | 2001 |
|---|---|---|---|---|---|
| **<100** | **(842)** | **(782)** | **(742)** | **(746)** | **(813)** |
| **Emp** | 28.11 | 27.76 | 28.76 | 29.18 | 28.72 |
| **VA/emp** | 22.702 | 24.279 | 36.162 | 25.818 | 30.292 |
| **GO/emp** | 67.266 | 68.352 | 97.166 | 69.317 | 81.701 |
| **>=100** | **(319)** | **(227)** | **(263)** | **(287)** | **(332)** |
| **Emp** | 1538.14 | 1277.90 | 1395.13 | 1962.40 | 1846.32 |
| **VA/emp** | 22.814 | 25.636 | 26.600 | 26.548 | 27.105 |
| **GO/emp** | 67.441 | 75.464 | 74.814 | 73.368 | 77.731 |

## Sector and e-commerce effects

### Table 8.12: SIC 52.1 Retail sale in non-specialised stores

| 52.1 | Either | | Buy only | | Sell only | | Both | |
|---|---|---|---|---|---|---|---|---|
| N=293 | Yes (87) | No (206) | Yes (52) | No (241) | Yes (13) | No (280) | Yes (22) | No (271) |
| Emp | 10406.47 | 532.04 | 6566.35 | 2794.66 | 2923.08 | 3489.15 | 23905.14 | 1804.61 |
| VA/emp | 17.778 | 19.420 | 16.675 | 19.419 | 23.155 | 18.736 | 17.207 | 19.072 |
| GO/emp | 65.186 | 65.668 | 64.111 | 65.830 | 70.173 | 65.309 | 64.781 | 65.585 |

### Table 8.13: SIC 52.2 Retail sale of food, beverages and tobacco in specialised stores

| 52.2 | Either | | Buy only | | Both | |
|---|---|---|---|---|---|---|
| N=249 | Yes (35) | No (214) | Yes (15) | No (234) | Yes (11) | No (238) |
| Emp | 824.14 | 111.29 | 344.93 | 202.93 | 1817.64 | 137.25 |
| VA/emp | 18.374 | 14.044 | 12.321 | 14.803 | 17.418 | 14.525 |
| GO/emp | 85.5 | 46.84 | 61.977 | 51.652 | 54.106 | 52.189 |

### Table 8.14: SIC 52.3 Retail sale of pharmaceutical and medical goods, cosmetic and toilet articles

| 52.3 | Either | | Buy only | | Both | |
|---|---|---|---|---|---|---|
| N=145 | Yes (39) | No (106) | Yes (24) | No (121) | Yes (10) | No (135) |
| Emp | 147.1 | 363.76 | 91.42 | 347.95 | 251.3 | 309.5 |
| VA/emp | 28.742 | 21.142 | 20.82 | 23.655 | 47.722 | 21.368 |
| GO/emp | 106.813 | 94.908 | 92.112 | 99.3 | 114.9 | 96.866 |

### Table 8.15: SIC 52.4 Other retail sale of new goods in specialised stores

| 52.4 | Either | | Buy only | | Sell only | | Both | |
|---|---|---|---|---|---|---|---|---|
| N=1033 | Yes (308) | No (725) | Yes (104) | No (929) | Yes (84) | No (949) | Yes (120) | No (913) |
| Emp | 1005.45 | 379.72 | 506.14 | 573.02 | 984.43 | 529.28 | 1452.89 | 449.76 |
| VA/emp | 28.442 | 24.993 | 25.881 | 26.037 | 28.182 | 25.830 | 30.842 | 25.387 |
| GO/emp | 78.954 | 66.827 | 70.556 | 70.430 | 77.562 | 69.812 | 87.206 | 68.239 |

## Sector, size and e-commerce effects

### Table 8.16: SIC 52.1 Retail sale in non-specialised stores

| 52.1 | Either | <100 | Either | >=100 | Buy only | <100 | Buy only | >=100 |
|---|---|---|---|---|---|---|---|---|
| N=293 | Yes (36) | No (123) | Yes (51) | No (83) | Yes (22) | No (137) | Yes (30) | No (104) |
| Emp | 33.17 | 30.77 | 17728.80 | 1274.88 | 33.41 | 30.98 | 11357.17 | 6435.28 |
| VA/emp | 13.147 | 13.605 | 21.047 | 28.037 | 12.748 | 13.622 | 19.555 | 27.056 |
| GO/emp | 56.926 | 56.057 | 71.017 | 79.910 | 56.987 | 56.136 | 69.336 | 78.599 |
| | Both | <100 | Both | >=100 | | | | |
| | Yes (11) | No (148) | Yes (11) | No (123) | | | | |
| Emp | 27.09 | 31.63 | 47783.18 | 3937.96 | | | | |
| VA/emp | 11.280 | 13.666 | 23.135 | 25.577 | | | | |
| GO/emp | 55.646 | 56.299 | 73.916 | 76.759 | | | | |

### Table 8.17: SIC 52.2 Retail sale of food, beverages and tobacco in specialised stores

| 52.2 | Either | <100 | Either | >=100 |
|---|---|---|---|---|
| N=249 | Yes (19) | No (178) | Yes (16) | No (36) |
| Emp | 32.11 | 25.07 | 1764.69 | 537.58 |
| VA/emp | 16.156 | 13.999 | 21.008 | 14.268 |
| GO/emp | 95.621 | 47.881 | 73.482 | 41.692 |

### Table 8.18: SIC 52.4 Other retail sale of new goods in specialised stores

| 52.4 | Either | <100 | Either | >=100 | Buy only | <100 | Buy only | >=100 |
|---|---|---|---|---|---|---|---|---|
| N=1033 | Yes (193) | No (553) | Yes (115) | No (172) | Yes (70) | No (676) | Yes (34) | No (253) |
| Emp | 30.95 | 28.56 | 2640.91 | 1508.75 | 30.99 | 28.99 | 1484.41 | 2026.64 |
| VA/emp | 28.045 | 25.041 | 29.107 | 24.837 | 27.022 | 25.694 | 23.532 | 26.954 |
| GO/emp | 78.786 | 66.012 | 79.235 | 69.446 | 71.992 | 69.04 | 67.599 | 74.144 |
| | Sell only | <100 | Sell only | >=100 | Both | <100 | Both | >=100 |
| | Yes (42) | No (704) | Yes (42) | No (245) | Yes (81) | No (665) | Yes (39) | No (248) |
| Emp | 34.83 | 28.84 | 1934.02 | 1967.27 | 28.9 | 29.21 | 4410.41 | 1577.44 |
| VA/emp | 28.288 | 25.671 | 28.076 | 26.286 | 28.803 | 25.455 | 35.079 | 25.207 |
| GO/emp | 78.551 | 68.766 | 76.572 | 72.819 | 84.78 | 67.433 | 92.246 | 70.4 |

## Stock trends by sector / size

### Table 8.23: SIC 52.1 Retail sale in non-specialised stores

| 52.1 | 1997 | 1998 | 1999 | 2000 | 2001 |
|---|---|---|---|---|---|
| **<100** | **(147)** | **(189)** | **(154)** | **(159)** | **(195)** |
| **Emp** | 29.18 | 28.44 | 29.98 | 31.31 | 31.63 |
| **Stock/Sales** | 0.0854 | 0.0709 | 0.0826 | 0.0730 | 0.0635 |
| **Stock/VA** | 0.3325 | 0.5334 | 0.3974 | 0.3563 | 0.2811 |
| **Stocks/Emp** | 4.3556 | 3.9977 | 4.3069 | 4.1114 | 4.2016 |
| **>=100** | **(149)** | **(129)** | **(136)** | **(134)** | **(139)** |
| **Emp** | 6284.85 | 5798.53 | 5038.83 | 7537.19 | 7779.83 |
| **Stock/Sales** | 0.0900 | 0.0860 | 0.0853 | 0.0870 | 0.0878 |
| **Stock/VA** | 0.3620 | 0.3010 | 0.3234 | 0.3165 | 0.3093 |
| **Stocks/Emp** | 5.7875 | 5.6864 | 6.2420 | 6.0060 | 6.1471 |

### Table 8.24: SIC 52.2 Retail sale of food, beverages and tobacco in specialised stores

| 52.2 | 1997 | 1998 | 1999 | 2000 | 2001 |
|---|---|---|---|---|---|
| **<100** | **(184)** | **(232)** | **(216)** | **(197)** | **(232)** |
| **Emp** | 24.90 | 29.63 | 26.46 | 25.75 | 26.13 |
| **Stock/Sales** | 0.0303 | 0.0310 | 0.0289 | 0.0326 | 0.0289 |
| **Stock/VA** | 0.1398 | 0.1254 | 0.1407 | 0.1433 | 0.1002 |
| **Stocks/Emp** | 2.0516 | 1.7086 | 1.7456 | 2.0513 | 1.8667 |
| **>=100** | **(47)** | **(45)** | **(58)** | **(52)** | **(53)** |
| **Emp** | 1173.11 | 561.18 | 881.09 | 915.15 | 977.81 |
| **Stock/Sales** | 0.0436 | 0.0352 | 0.0325 | 0.0385 | 0.0338 |
| **Stock/VA** | 0.2291 | 0.1996 | 0.1308 | 0.1383 | 0.1321 |
| **Stocks/Emp** | 2.9865 | 2.7604 | 2.2332 | 2.8171 | 2.4191 |

### Table 8.25: SIC 52.3 Retail sale of pharmaceutical and medical goods, cosmetic and toilet articles

| 52.3 | 1997 | 1998 | 1999 | 2000 | 2001 |
|---|---|---|---|---|---|
| **<100** | **(143)** | **(141)** | **(114)** | **(123)** | **(132)** |
| **Emp** | 32.13 | 27.00 | 25.28 | 28.25 | 29.31 |
| **Stock/Sales** | 0.0913 | 0.0929 | 0.0928 | 0.0846 | 0.0735 |
| **Stock/VA** | 0.4161 | 0.4583 | 0.5309 | 0.6276 | 0.3457 |
| **Stocks/Emp** | 7.1600 | 6.8957 | 7.9165 | 9.5432 | 6.6208 |
| **>=100** | **(32)** | **(23)** | **(25)** | **(22)** | **(22)** |
| **Emp** | 963.94 | 1740.57 | 847.12 | 1855.50 | 2065.32 |
| **Stock/Sales** | 0.0995 | 0.0863 | 0.0948 | 0.0924 | 0.0956 |
| **Stock/VA** | 0.5643 | 0.3846 | 0.3777 | 0.4265 | 0.5168 |
| **Stocks/Emp** | 6.4706 | 6.4156 | 6.1991 | 7.3486 | 8.0266 |

### Table 8.26: SIC 52.4 Other retail sale of new goods in specialised stores

| 52.4 | 1997 | 1998 | 1999 | 2000 | 2001 |
|---|---|---|---|---|---|
| **<100** | **(842)** | **(782)** | **(742)** | **(746)** | **(813)** |
| **Emp** | 28.11 | 27.76 | 28.76 | 29.18 | 28.72 |
| **Stock/Sales** | 0.1659 | 0.1560 | 0.1632 | 0.1532 | 0.1471 |
| **Stock/VA** | 0.8330 | 0.5145 | 0.6494 | 0.5941 | 0.4658 |
| **Stocks/Emp** | 10.7197 | 10.0178 | 11.9397 | 9.8419 | 11.8281 |
| **>=100** | **(319)** | **(227)** | **(263)** | **(287)** | **(332)** |
| **Emp** | 1538.14 | 1277.90 | 1395.13 | 1962.40 | 1846.32 |
| **Stock/Sales** | 0.1380 | 0.1402 | 0.1321 | 0.1330 | 0.1282 |
| **Stock/VA** | 0.4979 | 0.4634 | 0.4537 | 0.4105 | 0.9107 |
| **Stocks/Emp** | 9.3402 | 9.8143 | 9.5662 | 9.8392 | 9.5682 |

## Stocks, e-commerce effects by sector

### Table 8.30: SIC 52.1 Retail sale in non-specialised stores

| 52.1 | Either | | Buy only | | Sell only | | Both | |
|---|---|---|---|---|---|---|---|---|
| N=293 | Yes (87) | No (206) | Yes (52) | No (241) | Yes (13) | No (280) | Yes (22) | No (271) |
| Emp | 10406.47 | 532.04 | 6566.35 | 2794.66 | 2923.08 | 3489.15 | 23905.14 | 1804.61 |
| Stock/Sales | 0.0863 | 0.0765 | 0.0830 | 0.0786 | 0.1428 | 0.0764 | 0.0608 | 0.0809 |
| Stock/VA | 0.3368 | 0.3386 | 0.3534 | 0.3348 | 0.4596 | 0.3324 | 0.2248 | 0.3473 |
| Stocks/Emp | 5.4465 | 4.7800 | 5.1628 | 4.9380 | 9.6139 | 4.7626 | 3.6545 | 5.0853 |

### Table 8.31: SIC 52.2 Retail sale of food, beverages and tobacco in specialised stores

| 52.2 | Either | | Buy only | | Both | |
|---|---|---|---|---|---|---|
| N=249 | Yes (35) | No (214) | Yes (15) | No (234) | Yes (11) | No (238) |
| Emp | 824.14 | 111.29 | 344.93 | 202.93 | 1817.64 | 137.25 |
| Stock/Sales | 0.0572 | 0.03 | 0.0279 | 0.0342 | 0.0468 | 0.0332 |
| Stock/VA | 0.2417 | 0.126 | 0.1565 | 0.1413 | 0.1806 | 0.1405 |
| Stocks/Emp | 5.2943 | 1.707 | 1.9062 | 2.2308 | 2.8717 | 2.1807 |

### Table 8.32: SIC 52.3 Retail sale of pharmaceutical and medical goods, cosmetic and toilet articles

| 52.3 | Either | | Buy only | | Both | |
|---|---|---|---|---|---|---|
| N=145 | Yes (39) | No (106) | Yes (24) | No (121) | Yes (10) | No (135) |
| Emp | 147.1 | 363.76 | 91.42 | 347.95 | 251.3 | 309.5 |
| Stock/Sales | 0.0773 | 0.0889 | 0.0738 | 0.0882 | 0.0754 | 0.0866 |
| Stock/VA | 0.4465 | 0.6525 | 0.468 | 0.6227 | 0.3673 | 0.6141 |
| Stocks/Emp | 8.8644 | 9.3375 | 6.7783 | 9.6926 | 9.1764 | 9.2128 |

### Table 8.33: SIC 52.4 Other retail sale of new goods in specialised stores

| 52.4 | Either | | Buy only | | Sell only | | Both | |
|---|---|---|---|---|---|---|---|---|
| N=1033 | Yes (308) | No (725) | Yes (104) | No (929) | Yes (84) | No (949) | Yes (120) | No (913) |
| Emp | 1005.45 | 379.72 | 506.14 | 573.02 | 984.43 | 529.28 | 1452.89 | 449.76 |
| Stock/Sales | 0.1387 | 0.1514 | 0.1273 | 0.1499 | 0.1585 | 0.1466 | 0.1346 | 0.1493 |
| Stock/VA | 0.4211 | 0.5949 | 0.3821 | 0.5611 | 0.4738 | 0.5492 | 0.4180 | 0.5595 |
| Stocks/Emp | 10.0159 | 9.7669 | 8.5150 | 9.9896 | 11.4198 | 9.7014 | 10.3340 | 9.7764 |

**Stocks, e-commerce, sector and size**

(for non-disclosive sectors only)

### Table 8.34: SIC 52.1 Retail sale in non-specialised stores

| 52.1 | Buy only | <100 | Buy only | >=100 | Both | <100 | Both | >=100 |
|---|---|---|---|---|---|---|---|---|
| N=293 | Yes (22) | No (137) | Yes (30) | No (104) | Yes (11) | No (148) | Yes (11) | No (123) |
| Emp | 33.41 | 30.98 | 11357.17 | 6435.28 | 27.09 | 31.63 | 47783.18 | 3937.96 |
| Stock/Sales | 0.0962 | 0.0693 | 0.0733 | 0.0909 | 0.0425 | 0.0753 | 0.0792 | 0.0876 |
| Stock/VA | 0.4785 | 0.3367 | 0.2617 | 0.3323 | 0.2113 | 0.3671 | 0.2384 | 0.3235 |
| Stocks/Emp | 5.6990 | 3.8565 | 4.7697 | 6.3626 | 2.0056 | 4.2679 | 5.3033 | 6.0688 |

### Table 8.35: SIC 52.4 Other retail sale of new goods in specialised stores

| 52.4 | Buy only | <100 | Buy only | >=100 | Sell only | <100 | Sell only | >=100 |
|---|---|---|---|---|---|---|---|---|
| N=1033 | Yes (70) | No (676) | Yes (34) | No (253) | Yes (42) | No (704) | Yes (42) | No (245) |
| Emp | 30.99 | 28.99 | 1484.41 | 2026.64 | 34.83 | 28.84 | 1934.02 | 1967.27 |
| Stock/Sales | 0.1268 | 0.1560 | 0.1284 | 0.1336 | 0.1813 | 0.1516 | 0.1357 | 0.1325 |
| Stock/VA | 0.3680 | 0.6175 | 0.4110 | 0.4105 | 0.5527 | 0.5966 | 0.3949 | 0.4132 |
| Stocks/Emp | 8.9059 | 9.9388 | 7.7102 | 10.1253 | 12.6277 | 9.6757 | 10.2119 | 9.7753 |

| 52.4 | Both | <100 | Both | >=100 |
|---|---|---|---|---|
| N=1033 | Yes (81) | No (665) | Yes (39) | No (248) |
| Emp | 28.90 | 29.21 | 4410.41 | 1577.44 |
| Stock/Sales | 0.1359 | 0.1553 | 0.1319 | 0.1332 |
| Stock/VA | 0.4256 | 0.6146 | 0.4023 | 0.4119 |
| Stocks/Emp | 10.0178 | 9.8205 | 10.9908 | 9.6581 |

# 9 R&D and Innovation

*9.1 Background*

The concept that ICT and electronic business processes add to the capabilities of firms, and of the whole economy, to undertake and benefit from innovation is built into the EU's Lisbon strategy to strengthen Europe as a competitive, sustainable, knowledge based economy. Electronic transactions and exchanges, between firms and their business partners, are seen as an essential part of developing the information economy within this strategy.

Micro evidence that R&D and innovation contribute to productivity growth, and to other measures of competitiveness, has been researched from a wide range of sources. (Baldwin - Canada, van Leeween - Netherlands, Loof - Sweden, Clayton and Turner - DG Enterprise,). Up to now, however, evidence that ICT or electronic networks might affect the innovation process been limited. As part of this work programme, we have made an assessment of data from the UK version of the Community Innovation Survey, and the effects we are able to observe related to e-commerce data collected within the UK CIS, and information society data linked from other sources including the ABI.

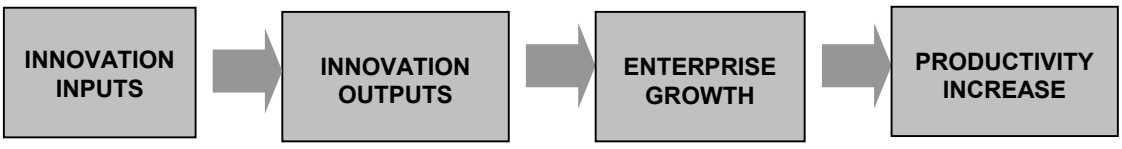
*9.2 Models for R&D and Innovation*

Micro data analysis of innovation drivers and effects have been based on a range of measures of outputs. In most, the measures of innovation itself are based on Oslo manual definitions of:

- use of innovative processes, new to the firm, or to the industry
- sales of innovative products, new to the firm, or to the market.

Measures of innovation input are based on information, relationships, skills, R&D spending (internal or external), research personnel, patents and licenses, and spending on other inputs (marketing, plant, other services) associated with innovation. Measures of innovation output have been based on competitive position / change in market share (Baldwin 2001, Clayton and Turner1996), or changes in productivity - measured as gross output or value added per employee (van Leeuwen).

Most of this work has been based on 'linear models' of innovation, conceptually predicated round innovation projects, with research activities, spending and other inputs leading to new product concepts, which result in measurable new product sales in markets and then leading to growth in output and / or productivity. This type of linear project model was included in the proposal for this study:




This type of model depends on separately defined inputs at each stage in the chain, and has no feedback mechanisms, which may be a weakness. However, most of the existing evidence, from CIS and its equivalents outside the EU and from private data, is structured in this way. Models based on feedback or on a cycle of innovation management, and data to support them, are still limited by data. (eg. A Virtuous Cycle - Innovation, Consumer Value and Communication, Kashani, Miller and Clayton, IMD)

*9.3 Studies based on UK CIS*

In parallel to work on this project, a research programme to test the productivity effects of innovation (as measured in the UK CIS for 1996 and for 2000) has been running in ONS over the last year, undertaken by Jonathan Haskel and funded by the Department of Trade and Industry. It was envisaged in our proposal that we would draw on this work, and it has so far focused on the 'linear model' approach, identifying inputs associated with product and process innovation, and the productivity outputs associated with product and process innovation.

Methodological issues associated with interpreting precisely what is measured in the surveys have been complex. The treatment of innovators who succeed in producing marketable new products without any reported spending or innovation activity has given problems in assessing probabilities in a reliable way. In addition, it is possible that interpretation by firms of apparently similar questions on innovation may have changed between 1996/7 and 2000/1, changing the 'amount' of reported innovation and its relationship to inputs. UK CIS results are consistent with the possibility that what firms may have declared as innovation in 1996/7 may be treated as 'normal business' in 2000/1.

Even with these limitations, the academic work on UK data has demonstrated, in regressions using both rounds of the data within CIS:
- statistically significant (but not always consistent) relationships between internal innovation expenditure at firm level, and success in marketing innovative products
- statistically significant relationships between existence of collaborative relationships and firm success in producing innovative product output, and also with the probability that a firm will adopt innovative processes (although the significance of the relationship depends on specification of the regression model).

To investigate productivity effects, this work has linked CIS2 data to UK structural business data for 1992-1996 (for manufacturing only) to test 'before and after' productivity for firms which do, and do not, innovate in product or process. A similar linking process and analysis (again for manufacturing only) has been applied to CIS3, looking at the period 1996-2000, although the first round of this work was undertaken with provisional firm output data (now updated in early 2003).

The CIS2 results (Criscuolo and Haskel ,ONS productivity workshop 2002) show:
- the significance of collaboration arrangements (along with plant purchase, training, patent information and other information sources) in process innovation adoption
- the strong relationship between process innovation and productivity growth.

CIS3 results from this programme have not yet been published, but early results show:
- links between internal innovation expenditure, collaboration arrangement (with varying degrees of significance) and adoption of innovative products and processes
- that product innovations in the CIS3 data-set are more likely to show significant links to productivity growth.

*9.4 Tabulations based on CIS3*

Evidence from the work programme above broadly supports the linear model round which our approach to innovation was specified, but suggests that there are both conceptual and measurement issues which may require its development. Rather than re-

invent, or pre-empt, the innovation work programme, to begin an analysis of the impact of electronic business processes with available knowledge we have:

- developed a limited number of tabulations based on CIS3 to show how robust a linear model might be
- sought evidence using e-commerce data within CIS3 for influence of electronic
- networks on relationships in the basic R&D => Innovation => Growth / Productivity model
- looked for evidence relating electronic network use to other drivers of the process, using linked data.

The tabulations are reported here only where statistically significant results arise.

*9.5 R&D => Innovation*

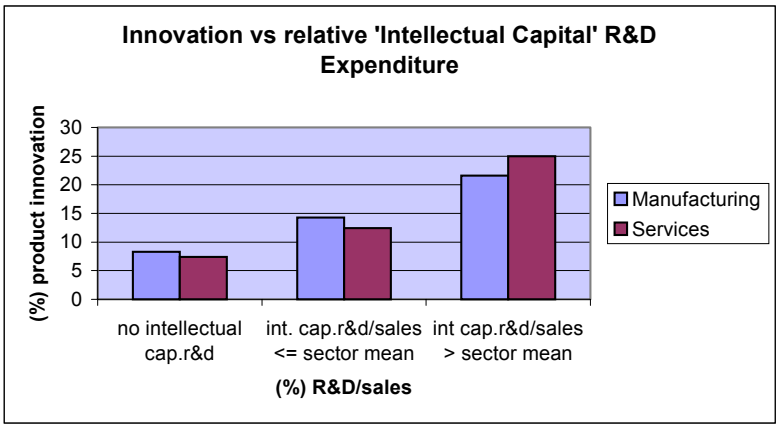
The relationship between R&D expenditure and product innovation output has been tabulated at two levels:

- expenditure on 'intellectual capital', on intramural R&D, external R&D and external knowledge acquisition (each of which is separately identified in CIS3)
- expenditure on total 'innovation related expenditure', which includes all of the above, plus machinery expenditure, design, training and marketing.

In the summary tabulations below we have first separated out the 'no R&D' firms, then classified each of the remaining firms within their two digit sectors according to whether they spend up to the mean R&D / sales ratio for R&D performers in the sector, or spend above the mean level. The innovation output of each group is then measured as percentage of new or improved products within firm sales.

For the majority of manufacturing and service sectors this shows that the firms which spend above sector average on intellectual property creation or acquisition also have significantly higher levels of new product (or service) content in their sales. This result remains significant at the 5% level taken across the whole of manufacturing and services, as shown in Figure 9.1. In both manufacturing and services, firms which spend anything have more sales from innovative products or services than firms which spend nothing, and firms spending above their sector means have more than firms spending below sector means. However, even the 1350 firms which report spending zero on R&D have, a mean innovation output of 7% to 8% of sales.

**Figure 9.1**

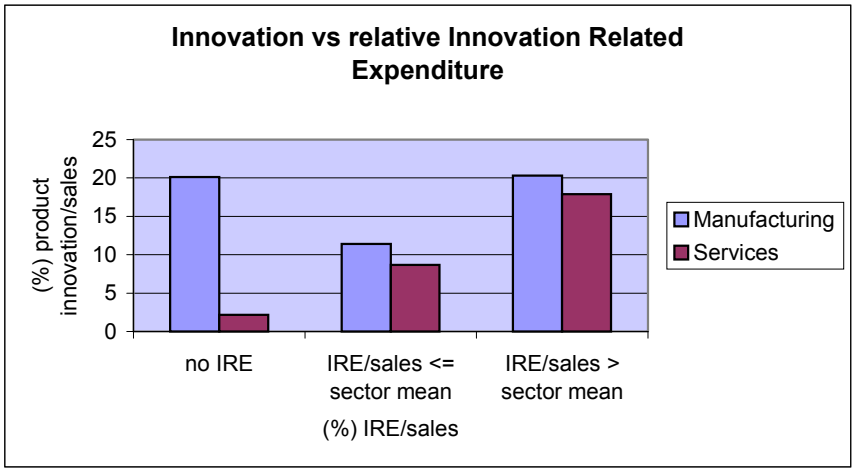



Source UK Community Innovation Survey 2000

A similar analysis taking into account all innovation related expenditure is slightly less clear; it is here that the issue of firms spending nothing shows the limits of a linear model. The data shows fewer than 30 manufacturing firms which spend nothing on any category of innovation related expenditure, but on average they have innovation output of 20% of sales - almost equal to the manufacturing firms that spend above their sector averages. It is clear that the survey shows innovation in some cases without measured expenditure. This may be due to timing, to response error, to lack of knowledge by respondents or to innovation expenditure being incurred outside the reporting unit (or even the country) where new products are sold  In any event, the range of innovation output within this group is so large that the mean result is not statistically significantly different from the 'low spending group', although the data still creates difficulties in regression work.

The data in Figure 9.2 seems to show R&D => innovation relationships across the services sector to be rather better behaved than for manufacturing. In both sectors, the relationship holds when we compare low spending vs. high spending firms at 2 digit sector level.

**Figure 9.2**




Source UK Community Innovation Survey 2000

*9.6 Innovation => output growth*

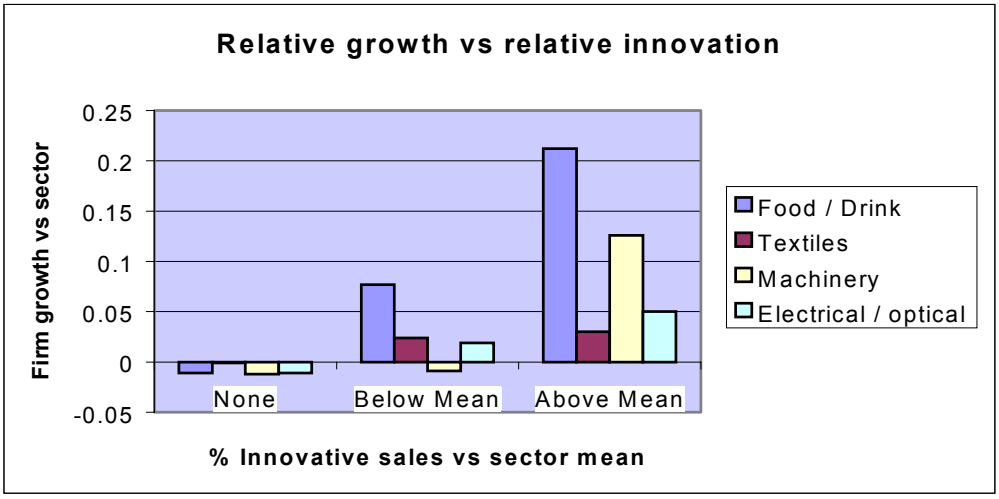
The tabulations below treat the innovation => growth data in a similar way, separating businesses surveyed in CIS3 into three groups:

- those reporting no new or improved products at all
- firms which innovate, but  whose proportion of new or improved output is less than the mean (excluding non-innovators) in their two digit SIC category
- innovators whose new or improved output equals or exceeds the mean for businesses in their SIC category (again excluding non-innovators).

For each group we have looked at the growth in sales reported within the CIS survey for the three years ending in the year for which innovation output  is measured. The analysis compares percentage growth performance of businesses relative to the mean growth of their 2 digit category - effectively relating change in the business' share of its sector to relative innovation activity. The results are shown below, for selected broad sector groups.

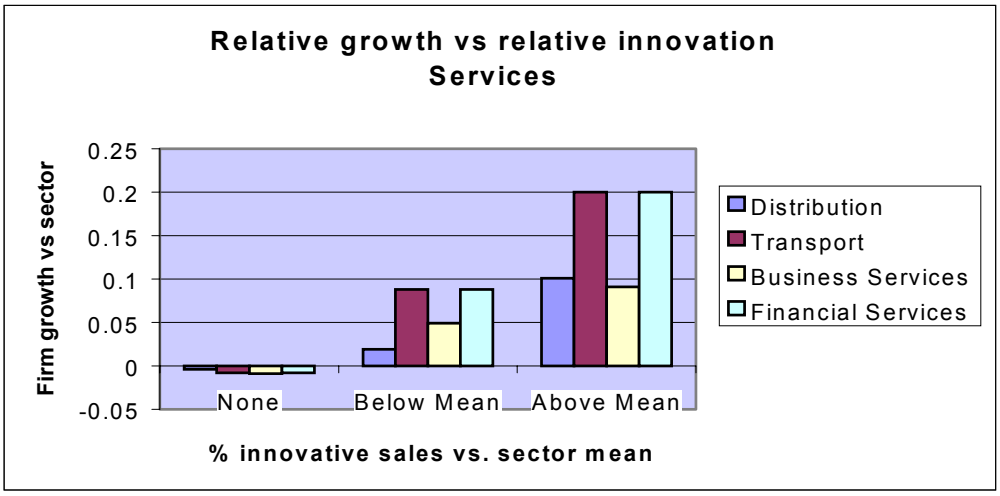
For most production and service sectors, these results show that firms with no innovation grow slowest - usually slower than the sector mean. Firms with moderate innovation do better (although not in every case), and firms with the highest innovation levels increase their sales significantly faster than the sector mean, and thus implicitly increase market share. The effect is present in both manufacturing and service sectors.

**Figure 9.3**




Source UK Community Innovation Survey 2000

**Figure 9.4**




Source UK Community Innovation Survey 2000

These relationships provide a base from which may be possible to assess anecdotal evidence that electronic interactions increase the benefits firms reap from innovation.

*9.7 e-Business effects and the linear model*

We have used CIS3 data to test:

- whether innovation output is influenced by the presence of electronic networks (measured by e-commerce use as captured in the CIS3 survey); the method used was to add 'electronic network use' as a term in the innovation output regression described in 9.3 above, and the result did not show a relationship at any significant level

- whether ICT and electronic transactions help, through improved marketing communication, to speed up or increase the sales growth effect associated with innovation; the method used was to test the tabulations shown in Figures 9.3 and 9.4 above for differences in the growth rates of firms with similar relative innovation rates, but with and without the use of electronic networks. In no sector examined was there a statistically significant effect on growth.

The evidence from these analyses suggests that direct, statistically significant, links between e-business process use and innovation output measures in our linear model may be difficult to find:

- at the innovation output stage because of the range of factors which impact performance, and the heterogeneity of innovation environments and types

- at the commercialisation (output growth) stage because we do not yet have a conceptual or data framework which captures marketing communication, although the ABI data-set identifies spending by firms on purchased marketing services.

### *9.8 Electronic networks and collaboration*

There is, however, a simpler qualitative variable which describes the behaviour of innovating firms which it has proved possible to correlate with electronic network use. In addition to the CIS regressions reported in 9.3 which confirm the significance of collaborative relationships, other international studies have shown collaboration as an important factor.

The CIS3 survey asks for responses on co-operation arrangements, first by asking whether firms engage in them or not, then if yes asking for the types of co-operations to be indicated in the following categories:

**Figure 9.5 Collaboration section of questionnaire**

| | Type of partner | Local | National | Europe | US | Other |
|---|---|---|---|---|---|---|
| Internal | Other enterprises within your enterprise group | | | | | |
| Market | Suppliers of equipment, materials, components or software | | | | | |
| | Clients or customers | | | | | |
| | Competitors | | | | | |
| | Consultants | | | | | |
| | Commercial laboratories / R&D enterprises | | | | | |
| Institutional | Universities or other higher education institutes | | | | | |
| | Government research organisations | | | | | |
| Specialised | Private research institutes | | | | | |

One possible impact of electronic networks in firms is to facilitate such collaborative arrangements, to increase the probability the firms are able to operate them, and to enable them to 'network' involving more partners. Although the survey does not tell us how many co-operation partners a firm has, it does indicate whether or not co-operation takes place and the number of different types and locations - which must as a minimum indicate the number of co-operators.

In order to increase the coverage of the sample on e-commerce use, we have matched the CIS responses with the ABI responses. The reason for this is that CIS response on e-commerce use is less comprehensive than that for ABI. The result is a data-set which contains nearly 7,000 observations with both e-commerce and collaboration responses.

The incidence of co-operation is surprisingly small, around 10% probability for those firms without electronic networks compared to a little over 15% for forms which indicate on one survey or the other that they use electronic networks for transactions. Regression including this relationship shows it as significant after controlling for firm size and sector. In addition, for the 800 firms which report co-operation arrangements, the use of electronic networks is associated with a larger spread of collaborator types (average number = 4.8) compared to those which do not (average number = 3.8).

The evidence from this linked data therefore suggests that use of electronic networks for commercial purposes is positively related to:

- the probability that a firm will be involved in collaboration for R&D / innovation
- the variety of collaborators that it will have.

However, as the mechanisms used for electronic research collaboration are in most cases different from those used for buying and selling, this is an indirect measure of behaviour. If we had data on use of networks for purposes other than buying and selling for a large sample (for example via the ABI, through direct questions on collaboration mechanisms in CIS, or from linked e-business questions on the e-commerce survey) it is likely that evidence for use of electronic networks to facilitate active research collaboration by firms would show up with greater clarity.

# 10 Conclusions and Next Steps

The work outlined in this report has demonstrated that data linking between surveys, and longitudinal linking across survey years, can help to identify market effects and firm behaviour influenced by electronic networks. It has shown:

- patterns of technology adoption
- turbulence, entry and exit in electronic markets
- productivity effects dependent on types of transaction
- price effects in markets, dependent on a range of structural factors still to be measured
- use of electronic networks for innovation co-operation between firms

An important conclusion from the work to date is that straightforward production function approaches to productivity assessment, or linear models for innovation effects, have their limits. For example:

- the price effects we have identified undermine normal measurement approaches to productivity assessment as a function of e-commerce use
- the innovation models we have investigated leave out of account a large number of intermediate influences.

Future ONS work, supported by the UK Department of Trade and Industry, will therefore focus on 'steps in the chain' from technology use to productivity, and from R&D and know-how to innovation. The approach we plan to take will be based on the Porter value chain model, examining the possible influence of ICT investment, and computer network use, on specific processes in firms. This approach has already been shown to work in this project insofar as we have demonstrated:

- the relationship between network use and innovative collaboration
- the major benefits from e-procurement

A programme of work is being formulated during 2003/4 to extend the approach to other business process areas, in consultation with firms and with government policymakers. This will also draw on the outcome of studies by other EU member states, and on work from the US, Japan, Australia and elsewhere, shared under the OECD programme of work on ICT impact.

Some of these new studies show that ICT use has a complex interaction with innovation in firms, and that the combination of new technologies, new processes and new outputs can be linked to productivity gains. Others show that different measures of ICT penetration in firms - based on people using technology - are useful explanatory variables. These measures are captured in the current Eurostat surveys on e-commerce and innovation (CIS3) as implemented in UK, and it is intended to test them in this programme of work.

**References**


*Section 2*

Business Data Linking; an Introduction, Mathew Barnes and Ralf Martin, UK Office for National Statistics, Economic Trends no 581 April 2002

ICT and GDP growth in the United Kingdom, a Sectoral Approach, London Economics 2003

ICT and productivity growth in the United Kingdom, Nick Oulton, 2001, Bank of England working paper no 140

*Section 3*

Innovations and productivity growth Chiara Criscuolo and Jonathan Haskel, 2002, www.ceriba.org.uk

*Section 5*

Prestwood D (2002) 2001 online trading by UK business. ONS First release, 8th October 2002

Atrostic BK and Nguyen S (2002) Computer Networks and US Manufacturing Plant Productivity, New evidence from the CNUS Data. Centre for Economic Studies, January 2002

Prestwood D (2002) 2001 e-commerce survey: online trading by UK business by sector. ONS First release, 31st October 2002

*Section 6*

Brynjolfsson and Hitt, 1995; Computers as a factor of production, the role of differences between firms, Economics of Innovation and New Technology

OECD, 2003; Seizing the Benefits of ICT - an international comparison of the impacts of ICT on economic performance, DSTI/IND/ICCP(2003)2

Hempell,T. 2002; Measuring the productivity impacts of ICT at firm level, Centre for European Research

Mika Maliranta and Petri Rouvinen, 2003; Productivity effects of ICT in Finnish business, discussion paper 852, Research Institute of the Finnish Economy

Van Leeuwen and van der Weil, 2003; ICT, innovation and productivity, CAED conference paper, London 2003

Atrostic BK and Nguyen S, 2002; Computer Networks and US Manufacturing Plant Productivity, New evidence from the CNUS Data. Centre for Economic Studies, January 2002

Presentation by Michael Nenninger, Siemens, to DG Enterprise e-business w@tch workshop, Brussels, November 2002

*Section 7*

Michael Smith, Joseph Bailey and Erik Brynjofsson, 2000, Understanding Digital Markets; Understanding the Digital Economy, ed. Brynjolfsson and Kahin, MIT Press

E-business Impact Programme (EBIP) at www.oecd.org/sti/information-economy

*Section 8*

Pricewaterhouse Coopers, July 2000, e-commerce impact study, Retail Overview, at www.ecrnet.org/conference/index.html

*Section 9*

Criscuolo C and Haskel J (2002) Innovation and Productivity Growth in the UK. *paper for ONS / DTI productivity workshop, November 2002*

John Baldwin and David Sabourin, 2001; Impact of the Adoption of Advanced Information and Manufacturing Technologies on Firm Performance in the Canadian Manufacturing Sector, OECD reference DSTI/EAS/IND/SWP/AH(2001)5

Tony Clayton and Graham Turner, 1996, Building Business, Panorama of EU Industry, DG Enterprise

George van Leeuwen, 2002; Linking innovation to productivity growth using two waves of CIS, STI working paper, OECD

K.Kashani, J.Miller and T.Clayton,2000; A virtuous cycle - innovation, consumer value and communication, IMD Lausanne