INNOVATION AND COMPETITIVENESS: TRENDS IN UNIT PRICES IN GLOBAL TRADE

Raphael Kaplinsky,
Institute of Development Studies,
University of Sussex,
Brighton, and
Centre for Research in Innovation Management,
University of Brighton

and

Amelia Santos Paulino
Institute of Development Studies,
University of Sussex,
Brighton

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SUMMARY

This paper seeks to build on theory, to develop new methods for understanding the nature and basis of sectoral and national competitive advantage, and to do so with a temporal perspective.

Neo-Schumpeterian and evolutionary economics perspectives are in large part built around the concepts of barriers to entry and core competences. Unless these are established, individual firms, networks of firms and countries will be unable to generate sustained income growth. There is no one measure which adequately reflects these barriers to entry, and much of the research has been concerned to generate proxies, each of which is in itself partial, but which together provide for a comprehensive picture.

During the late 1970s, preliminary work was done on the unit price of UK trade as an indicator of relative technological competence. However, this approach has largely been neglected since then, receiving only sporadic attention in the US literature, and at high levels of product aggregation. This paper utilises this approach to try and reflect the dynamic process of shifting competitive advantage in the global economy. Its distinctive feature is the level of detail – six-digit trade classifications – and its breadth of coverage, being applied to seven sets of sectoral classifications involving more than 12,000 product groups. The data-set relates to EU imports of manufactures between 1988 and 2001.

Keywords

Technology and trade
Factor intensity and trade
Terms of trade
Global competitiveness
Fallacy of composition

1. Indicators of innovation

Schumpeter's model of innovation is founded on the role which barriers of entry provide in sustaining innovation rents. If barriers to entry are substantial, competition is limited, and price-competition is held at bay and, if the innovation is attractive to users, incomes are high and sustainable. Without innovation or if barriers to entry are low, price competition drives producers out of production or, at least, in a Malthusian race to the bottom in living standards.

How might we know if innovation is indeed being sustained? If we work at the plant- or firm-level, this is a matter for empirical investigation, examining production processes (reflected for example in factor productivity, quality, lead time and other indicators), products (for example, the introduction of new or differentiated products) and function (whether firms are involved in production, design, marketing or other links in the value chain).[1] However, once the focus moves beyond the plant and the firm, the measurement of innovation becomes more difficult.

Typically, in assessing rates of innovation in clusters, sectors or countries, innovative activity is reflected by the use of one or both of two indicators – an *input indicator* (for example, R&D expenditure, percentage of skills of different sorts in the labour force) or an *output indicator* (notably patents). Clearly, none of these input or output indicators of innovation are ideal. Input indicators are bedevilled by measurement problems, the effectiveness with resources are utilised, and their lack of recognition of processes of incremental technical change. Output indicators are hampered by the differential patenting activity between sectors. We live in a world of the second-best (or perhaps the fourth- or fifth-best!). So, at best, we need to apply a range of innovation indicators, in each case interpreting the results with care.

A further indicator of innovation promoted during the early 1980s is the unit price of output. To the best of our knowledge, this indicator was first used in 1977 in a study by the then National Economic Development Office focusing on UK competitiveness (Stout, et al, 1977). This was picked up by Pavitt Keith and his SPRU colleagues in their 1980 volume entitled *Technical Innovation in British Economic Performance.* In his Introduction Pavitt concluded that "[c]ompared with Germany and other major competitors, Britain is producing unsophisticated machinery and consumer durable goods, requiring relatively few innovative activities, and *having relatively low unit values* and value to weight ratios" (emphasis added) (Pavitt, 1980: 7). This measure was used by SPRU colleagues to assess the competitiveness of the UK defence sector (Kaldor, 1980), textile machinery (Rothwell, 1980), and electrical power tools (Walker and Gardiner, 1980). In recent years there has been renewed interest in the use of unit prices as an indicator of trade specialisation in US imports (Schott, 2002), quality and product innovation in EU imports (Aiginger, 2000), in analysing the impact of trade on employment in Italy (Celi and Smith, 2003), and in models of import prices in which exporters to the *euro* area set export prices through a combination of a mark-up on their production costs (the degree of exchange rate pass-

[1] Traditionally innovation has been thought of in relation to process and product. However, recent work on global value chains has thrown the spotlight on two other categories of innovation – functional upgrading (repositioning within the chain) and moving between chains. See the various contributions in Gereffi and Kaplinsky (eds.) (2001).

through) and pricing to market (Anderton, 2003). None of these studies – both in the 1980s and those of a more recent nature - looked in any systematic way at *trends* in unit prices, which is the focus of this paper.

The rationale for using unit prices as an indicator of competitiveness is that it harks back to Schumpeter's discussion of innovation – low barriers to entry allow competitors into the market which has the effect of driving prices (and hence incomes and margins) down. This indicator suffers from two key assumptions. The first is that cost-reducing technical change is neutral across sectors, since if costs fall more than prices, than a fall in unit prices may not necessarily be associated with a decline in margins and incomes. Whilst this is notably a false assumption with regard to the electronics sector, there is no empirical basis for arguing the validity of this assumption across other sectors. The second assumption is that the degree of value added in global trade is either unchanged, or that the changes are invariant across sectors.. This assumption is also problematic, since the fracturing of global production processes has meant a thinning of value added in many products (Feenstra, 1998, IMF, 2002). But once again we have no basis for arguing in any systematic way that this is uneven across sectors. One way around these objections is to link the discussion of unit-prices to that of market shares – that is, a combination of rising unit prices and rising market shares may indicate a virtuous path of innovation which provides the product rents to sustain growing incomes; and vice versa for falling prices and falling shares. This is a technique used in an embryonic form by Roy Rothwell in his study of textile machinery (op cit, 1980), and developed further by Jeff Readman and myself in a study of the global furniture industry (Kaplinsky and Readman, 2004).

However, in this paper our primary objective will be to focus on unit prices alone as an indicator of innovation and competitiveness. We will work with the hypothesis that there is a direct relationship between unit price performance and innovative capabilities – rising unit prices are said to reflect growing product innovation and/or margins protected by barriers to entry, and conversely, falling unit prices reflect the inability to erect barriers to entry and/or to augment products. (More accurately, the *relative* tendency for prices to rise or fall between different sectoral classifications). In doing so we are fully aware of the dangers of using unit-prices as a measure of innovation, but we do so in the belief that used in conjunction with other innovation indicators, it does offer the possibility of enhancing our understanding of the outcome of innovation processes. This is, therefore, one arrow in an arsenal targeting a fuller reflection of innovation processes, and the paper should be read with this health-warning in mind. Our secondary objective is to produce detailed sectoral taxonomies which others can use in sectoral analysis. Here we have been guided by the need to disaggregate data to the maximum extent, since our complementary work shows that the greater the degree of disaggregation, the greater the utility of the data; [2] these detailed taxonomies can be drawn down from the website we will be developing (see www.ids.ac.uk/global).

[2] Briefly, the problem with much macro-economic analysis (for example, in the relationship between trade and employment and on the terms of trade) is that it is conducted at a two-/three-digit level of disaggregation. Our data shows that it is necessary to go to a much higher degree of disaggregation if price and industry trends are to become visible. Similar conclusions are reached by Celi and Smith (2003) in their analysis of the employment effect of Italian imports from low-wage economies.

The dataset we use is the EUROSTAT COMEXT database, which provides monthly data at the eight-digit product level of European imports and exports in value and volume from 1988. With the exception of a single classificatory system (see below) we confine our analysis to the unit prices of manufactured products. We have also expanded all of the examined sectoral classifications to the six-digit HS level.

In determining the trend in unit prices we began by using the augmented Dickey-Fuller unit root tests (the ADF test) and the Kalman Filter methodology. The ADF test is based on a regression of the form: $\Delta y_t = \alpha + \phi y_{t-1} + \sum_{i=1}^{T} \Theta \Delta y_{t-i} + \delta t + \varepsilon_t$, where ε_t is a random error term, and α and t are a constant and time trend, respectively. The ADF test corresponds to the value of the t-ratio of the coefficient ϕ. The null hypothesis of the ADF test is that y_t is a non-stationary series, which is rejected when ϕ is significantly negative. Twelve lags, a constant, and a time trend were included in the ADF regressions of the levels of the variables. For the level variables, the sample is 1988-2001 monthly data. The ADF test determines whether price trends are indeed to be found. We then used a subsidiary t-test to determine the significance of the slope of these lines - a minus result indicates a falling trend in prices (the larger the magnitude the greater the fall in prices) and conversely for rising prices; these are characterised by various levels of statistical significance.

Unfortunately, the limitations imposed by our data base – only 13 years' data – diminished the likelihood of our finding statistically significant price trends over the whole period, and particularly in determining whether there have been breaks in trend (for example after the 1997 East Asian crisis). There is no way of getting around these data limitations and to the best of our knowledge there is no other statistical method which has the rigour to allow us to conclude whether price trends do exist over a 13 year period.[3] We have therefore estimated unit prices by using two-year moving average prices – for the initial period (1988/9) and for the final period (2001/2)

In summary, then, our methodology involves an examination of unit-price trends of EU imports between 1988 and 2001. Our indicator in the analysis of sectoral classifications will be the proportion of sectors showing falling relative prices.

2. Sectoral differentiation and unit price trends

How can we put this price data to use in illuminating the innovation content in global production and trade? One way is to examine the unit-price behaviour of products emanating from different countries and groups of countries – the function of this is to highlight the inter-country distributional impact of innovation and the robustness of national systems of innovation. We have undertaken this in a complementary paper with results which show a clear inverse relationship between per-capita incomes of country groups and the unit-price of their exports to the EU (Kaplinsky and Santos-Paulino, 2004). But resources are more meaningfully allocated at the sectoral level

3 In reaching this decision we consulted widely within the profession. One gathering at which we discussed methodology was focused on the terms of trade of primary product producers. It concluded that their time series also was too short to make meaningful use of the ADF and KF techniques – in their case, their data-set went back to 1926!

and it is at this level that our analysis is pitched in this paper. Our question is: *to what extent do changes in unit prices reflect sectoral characteristics?* From this it may be possible to make judgements about the degree of innovation involved in different sectors and the extent to which, by erecting barriers to entry, this determines the distribution of returns from production.

In distinguishing sectoral taxonomies to be used in this analysis we draw on the taxonomies which have been identified by other researchers interested in these issues.[4] Table 1 lists the characteristics of 23 studies which we were able to identify and which generated sectoral taxonomies. The elements of these various studies which we highlight (and use to select categories for sectoral price analysis) are:

- the purpose for which the taxonomy is constructed
- whether they focus on product or process characteristics
- whether they use ordinal or cardinal measures (this has an important bearing on statistical and econometric analysis)
- whether they use single criteria (for example, R&D intensity) or multiple criteria (for example, R&D and advertising intensity)
- the type of data which is involved (for example, trade data, industrial statistics, innovation data)
- the level of detail and the number of sectors involved
- the sectoral categories identified
- the basis for allocating individual sectors into these categories
- the time period of this data
- the source of this data

4 Peneder (undated) provides a helpful review of many sector taxonomies, including many of those included in Table 1. We agree with his observation that “in contrast to the prominent attention it is given in various sciences such as biology, psychology and sociology, the proper construction and use of classification has remained highly under-researched in the realm of economics. We still find little or no methodological debate and a striking lack of awareness for the different approaches pursued (p. 6).

Table 1: Summary of Sector Taxonomy Studies

Study	**Purpose**	**Indicator** **Process/ product** **Type**	**Single or multiple criteria** **Ordinal or cardinal measurement**	**Type of data**	**Level detail**	**# sector categ-ories/ subsec-tors**	**Categories**	**Basis of allocation**	**Time period**	**Source of data**
Mayer, Butkevicius and Kadri (2002)	Identify sectors of dynamism in trade	Products Dynamic products	Multiple Cardinal	Trade data	3-digit	20/20	Dynamic products	Authors' use of analytical criteria	1980-1988	COMTRADE – SITC (REV3@?)
Jaffee, Steven and Gordon (1993); World Bank (1994)	Identify high margin export sectors	Product Income elasticity of demand	Single Cardinal	Trade data	3-digit	7/17	Income elastic products	Authors' use of analytical criteria	Late 1980s-early 1990s	SITC REV2
Pavitt (1984)	Identify sectors of technological intensity and their links with firm-size	Process Nature of innovation	Multiple Ordinal	Database of innovations	11 2-digit, and 26 3- and 4-digit ISIC	4 (37)	Supplier-dominated; Production intensive (Scale-Intensive and Specialised Suppliers); science-based	Judgement of engineering experts	1945-1980	Significant UK Innovations – SPRU database
Leamer (1984)	Test the Heckscher-Ohlin theorem on the determinants of international trade.	Process Factor intensity	Multiple Cardinal	Trade data, skills, factor inputs	2-digit 3-digit	10 (61)	2 primary products (petroleum and raw materials), 4 crops (forest products, tropical/ Mediterranean agricultural products, animal products) and 4 manufactures (labour-intensive, capital-intensive, machinery, chemicals).	Author's judgement, secondary sources, use of analytical techniques	1948-1973	Trade data from UN sources; capital from national accounts, resources from various sources, skills from ILO Yearbook. Sectoral definitions of capital and labour intensity based on 1963 US data, and drawn from Hufbauer 1970.
UNIDO (1988)	Explore LDC capability in capital goods production	Process 103 indicators	Multiple Cardinal	Unspecified, but focus on manufacturing process	High	4 (1,100)	capital goods used: to produce other capital goods; used to produce intermediate goods; used to produce consumer goods; used across sectors.	Engineering experts using analytical criteria	Unspecified – but 10 year period of allocation	UNIDO database

Table 1: Summary of Sector Taxonomy Studies (cont.)

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Forstner and Ballance (1990)	Identify determinants of global trade	Process and product Factor endowments; product cycle goods	Multiple Cardinal	Capital, labour (skilled and unskilled); trade data	3-digit	4/25 3/147	High- and low- growth, labour- and capital-intensive Ricardian, H-O, product cycle	Authors' use of analytical criteria; secondary sources	1970 and 1985 1960s, 1970s and early 1980s	ISIC (national accounts), ISCO (ILO) with concordance to SITC US
Wood (1994) Wood, and Berge (1997); Wood and Mayer (2002) Wood and Mayer (1998)	Explain distribution of income and employment Explain differential LDC exports of manufactures Explain differential LDC exports of processed and unprocessed primary products	Process Factor intensity	Multiple Cardinal Multiple Cardinal Multiple Cardinal	Labour (skilled and unskilled); trade data Skills and trade data Trade data, educational data and resource data	3-digit 2- and occasional 3-digit 3-,4- and occasional 5-digit	3 (NA) 4 (11) 6 (188)	Primary, processed primary, narrow manufactures Unprocessed- and processed- primary, labour- and skill-intensive manufactures Processed/unprocessed minerals, metals, fuels; Processed/unprocessed dynamic agricultural products; Processed/ unprocessed static agricultural products	Authors' use of analytical criteria; secondary sources Judgement of author	US 1981, UNIDO early 1990s	ISIC with concordance to SITC COMTRADE Skill levels from Barro and Lee; SIC concordance to SITC; SITC COMTRADE Skill levels from Barro and Lee; SIC concordance to SITC; SITC COMTRADE ; dynamic income elastic trade data from unpublished sources
UNCTAD 1996	Explain source of upgrading in NIEs	Process Skill-, capital-technology and scale-intensity	Multiple Ordinal	Trade data	2- and occasional 3-digit	5 (38)	Non-fuel primary; labour- and resource-intensive; low-skill, low-capital and low-technology; medium- skill, medium-capital and medium technology; high- skill, high-capital and high technology;	Authors' use of analytical criteria; secondary sources	1965, 1975, 1985 and 1994	SITC COMTRADE

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Marsili (2001)	Identify sectors of dynamic comparative advantage	Process Various, based on limitations of R&D (input) and patent (output) statistics	Single Cardinal	Various – incl patents, R&D, skills, citations	Mostly 2-digit SIC, some 4-digit	Various but key is 5 (18)	Learning-regimes: - science-based; fundamental process; complex systems; product engineering; continuous process.	Author’s use of analytical criteria	Various – mostly 1990s	US National Science Federation SPRU database on patents and global firms PACE database on European innovation
Choudhri and Hakura (2000	Identify manufacturing sectors with rapid productivity growth	Process Total Factor Productivity	Single Cardinal	Input and output data	2-digit	4 (9)	Non-Manufacturing; High-, medium- and low-TFP growth	Use of analytical criteria	1970-1993	OECD International Sectoral Database.; UNIDO Industrial Statistics Database (Indstat3) UN SNA; Feenstra, Lipsey and Bowen (1997)
OECD (1992)	Identify high-technology sectors to promote industrial development	Process R&D intensity in production (direct and indirect)	Multiple Ordinal	R&D data	2- and occasion al 3-digit	6 (36)	Non-fuel primary; labour-intensive manufactures; differentiated products requiring specialised suppliers; scale-intensive manufactures; science-based manufactures	Authors’ use of analytical criteria	Late 1980s	US R&D data converted to SITC data
OECD (1994), updated 2003.	Identify high-technology sectors to promote industrial development	R&D intensity in production (direct and indirect)		R&D data	3- and occasion al 4-digit	4 (27)	High-tech; medium-high etch; medium-low tech; low-tech	Authors’ use of analytical criteria	Early 2000s	R&D data from 10 OECD countries converted to SITC data
Hatzichronoglou, (1997)	Identify high-technology sectors to promote industrial development	R&D and innovation intensity of products		R&D and production data	4-digit	9 (76)	Aerospace; computers-office; electronics-telecomms; pharmacy; scientific instruments; electrical machinery; chemistry; non-electrical machinery; armaments	Judgement of engineering experts	1988-1995	R&D data from 6 OECD countries, converted to SITC data

Table 1: Summary of Sector Taxonomy Studies (cont.)

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EUROSTAT (1995), cited in Pearson and Jagger (2003).	Identify sectors with technological intensity	Process Skills	NA Ordinal	NA	2-digit SIC	6 (78)	Primary production; High-tech Manufacturing; Medium-high-tech-manufacturing; low-tech-manufacturing; Knowledge-intensive services; Other services	NA	NA	NA
Lall (2000)	Identify export sectors which promote dynamic comparative advantage	Process Technology-intensive and capability building criteria	Multiple Ordinal	Not specified	3-digit SITC Rev2	5 (9) (230)	Primary products; Resource-based products; Low-tech products; Medium-tech products; High-tech products	Judgement of researcher	Late 1990s	UN COMTRADE
Acha et al (2002)	Identify complex production system products – “high cost, engineering-intensive products, systems, networks and constructs”	Process Unit costs, volumes, customisation, design variety, diversity of knowledge; number components/subsystems, interaction with users	Multiple Ordinal	Gross wages/ employee; purchases of IT services; purchases of telecoms; expenditure on branding and advertising	3-digit and 4-digit SIC92	1 (503 4-digit and 253 5-digit)	Complex production system products	Judgement of authors and use of analytical criteria	1997-1999	UK Annual Business Inquiry
Schmoch et al (2003)	Link between technology and economic performance	Process Innovation and production indicators	Single Ordinal	Patent statistics and SIC categories	2-digit SIC and 65 IPC patent classes	44 SIC 65 IPC	NA	Use of analytical criteria	1997	European Patent Office

Study	Purpose	Indicator Process/ product Type	Single or multiple criteria Ordinal or cardinal measurement	Type of data	Level detail	# sector categ-ories/ subsec-tors	Categories	Basis of allocation	Time period	Source of data
Neven (1994)	Identify factor content of trade in order to asses welfare impact of trade between EU and E. Europe.	Process Labour-intensity, capital-intensity, wage levels, skills	Multiple Cardinal	Wages, value added, investment, skills	NACE 3 and some 4 digit	5 (140)	(i) *High-tech, high human capital* (high wages/VA, high avg wage, high white collar) (ii) *High human capital, low invest* (low invest/VA, high avg wages, high wage/VA) (iii) *Lab intensive* (low avg wage, high wage/VA, low invest/VA) (iv) *Labour and capital intensive* (high invest/VA, low avg wage, low white collar, intermediate wage/VA) (v) *Human capital and invest intensive* (high avg wages, intermediate wages/VA, high invest/VA, high white collar)	Cluster analysis	1985-1990	SIC - Germany (triangulated with other 11 EU countries)
Davies and Lyons et al (1996)	(i) assemble a Europe-wide industrial database (ii) develop new taxonomies of industrial structure	Process Innovation	Multiple Ordinal (binary category)	Scale, R&D, advertising, ownership	3-digit NACE	100 (4)	Based on advertising and R&D	Use of analytical criteria (R&D and advertising intensity)	1987	Advertising – UK commercial agency; R&D from UK and Italy census of production
Aiginger (2000)	Identify sectors where quality rather than price is significant factor	Product Quality-elasticity	Single Ordinal	Trade – unit values and trade balance	3 digit SIC	3 (93)	High, medium and low “Revealed Quality Elasticity”	Original indicator using trade (price and volume) data	1988-1998	EUROSTAT
Sutton (1998)	To explore the link between R&D intensity and concentration	Process and product Innovation intensity and product homogeneity	Multiple Ordinal	R&D, advertising intensity, product homogeneity	4- and some 5-digit SIC	2 (34 and 119)*	R%D Intensive and Low R&D, low-advertising intensive	Use of analytical criteria	1977	US Census of Manufacturing and Fair Trade Commission

* Sutton’s analysis uses 34 R&D intensive sectors (R&D/sales ratio of >4%) and bottom 50 sectors with low R&D and advertising intensity control group. However, the 50 low-innovation control group is never indentified so we use the 119 sector population of low-innovation intensive firms from which the 50-sector sample was constructed

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Each of these elements is relevant for different uses. However, in choosing a set of classifications for price analysis in this innovation-focused paper, we have taken account of the following issues:

- Loosely-speaking it is possible to distinguish three types of sectoral classifications – those focusing on product characteristics (income elasticity, for example), those on factor content (notably capital and labour intensity), and those targeted at innovation- and technology-intensity; clearly it is the latter focus which will inform this unit-price analysis

- Many of the sectoral classifications which have been developed use very old data. The problem is not just with the age of the data, but also that where they involve structural relationships (for example, factor intensity) the nature of these input-output relationships might have changed significantly over time. (This is particularly true of the classic study by Leamer which was published in 1984 using data from the 1970s and which is still widely used in the definition of factor-intensity – Leamer, 1984).

- We have striven to achieve as much details as possible and have therefore tried to go for maximum sectoral disaggregation, in all cases extending the initial two- and three-digit level classifications of the original sector classifications to the six-digit level. The reason for this is that our complementary analysis has shown that the incidence of unit-price trends is directly related to the degree of disaggregation (Kaplinsky and Santos Paulino, 2004)[5]

- With the exception of a group of resource-based industries identified by Lall, we have confined the analysis to manufacturing sectors. Resource-based sectors have already received extensive price-analysis (notably by the terms of trade literature – see, for example, the classic by Singer, 1950) and our ultimate objective is to chart the growing competitiveness in the manufacturing sector and changes in the intra-manufacturing sector's terms of trade. Services are excluded because they are not covered in the EU COMEXT database.

Based on these criteria, we have tested unit-price trends for the following taxonomies:

- Davies and Lyons' distinction between sectors with no quality focus, R&D intensive sectors and R&D+advertising intensive sectors at the two-digit level (we have extended this to the four-, and six-digit level). This has the advantage of recognising both formal R&D inputs and firms' investment in market-based and product-oriented intangibles. It is also based on the application of criteria (the share of R&D and advertising in sales). The downside is that these sectors are defined on the basis of 1987 data.

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5 As Schott observes, "using [aggregated] industry-level data [is] problematic because much of the factor proportions action occurs at a level that is hidden from researchers" (Schott, 2002: 3).

- Neven's distinction between high-tech/high human capital, high human capital/low invest, labour intensive, labour/capital intensive, and human capital/investment intensive sectors has two primary strengths. First it is based on multiple criteria, and is trade-focused. Secondly the sector categorisation is derived from cluster analysis which is an inductive approach which arguably better reflects sector characteristics than the didactic and often personal methodologies used by other authors. The downside is that it reflects (West) German economic structure (albeit triangulated with other industrially advanced countries) and is dated (1985-1990). We have extended his four-digit level taxonomy to thesix6-digit level.

- UNCTAD's categorisation of labour/resource intensive, low-skill/low-tech/low capital intensive, medium-skill/medium-tech/medium-capital intensive, and high-skill/high-tech/high-capital intensive sectors at the three-digit level (we have extended this to the six-digit level). The strengths of this nomenclature are that it is linked to an analysis of inter-country technological capabilities and is based on multiple criteria (more closely reflecting the complexity of factors affecting competitiveness). On the other hand, much of the data on which these judgements were made – based on an assessment of individual UN desk-officers rather than the application of criteria – is dated.

- The OECD process categorisation is based on R&D inputs into production and distinguishes low technology, medium-low technology, medium-high technology and high-technology sectors. It uses data from the second half of the 1990s, but is only based on a single criterion (which we know from the literature provides only a partial perspective on innovation) and is defined at a high level of aggregation. We have extended their two-digit level taxonomy to the six-digit level.

- Lall's distinction between resource-based, low technology, medium technology, engineering and high technology sectors at a three-digit level (although we have decomposed this to the six-digit level). This categorisation has the distinction of being recent (late 1990s) and detailed; however, the downside is that the allocation of sectors reflects the judgement of the author, which is inevitably based on partial knowledge.

- The COPS classification of sectors provides a new and stimulating taxonomy of a specific category of sectors. We have extended their three-digit classification to the four-digit level.

- UNCTAD recently produced an analysis of the 20 most rapidly growing products in global trade (Mayer, Butkevicius and Kadri, 2003). We have excluded resource and primary products, and have expanded the 13 three-digit manufacturing classification to 237 six-digit sectors.

- Sutton's classification of R&D-intensive sectors.

In total we therefore examined the unit price behaviour of 12,4390 sub-sectors. In drawing on these technological trajectories we have had to undertake a great deal of work in translating the various nomenclatures used - SITC (various Revisions), ISIC (various revisions), NACE (various revisions) and ISCO – into the HS nomenclature utilised in the EU COMEXT database. In deepening the detail of the analysis we have also extended the two- and three-digit classifications to four- and six-digit levels. Inevitably there are also some cases where the translation between the process-oriented ISIC production taxonomies are not adequately captured by the product-oriented trade classifications (HS/SITC), although we have utilised the established protocols for this translation.

3. Results

So what emerges from the analysis of price trends of the various sectoral taxonomies? It is possible to conclude from Table 2 that the median proportion of subs-sectors showing a negative unit-price performance in the 1988-2001 period is around two-thirds. For example, the proportion of sectors with falling prices in the four largest sectoral investigations (OECD, UNCTAD, Lall and Neven) is 66 percent, 65 percent, 63 percent and 62 percent respectively. We will therefore use this figure of 60-65 percent of sectors displaying falling unit prices as a benchmark for the "average" unit-price performance of sectoral classifications selling into the EU.

The data can be interpreted in two ways. The first is in pursuit of the hypothesis that price reduction is a reflection of low barriers to entry and that technology, innovation and knowledge are important barriers to entry. Therefore, the greater the technology-, innovation- and knowledge-intensive the product, the less likely that its prices will fall. An alternative use of the data is to assume that the proportion of sectors with falling prices will be lower for technology- and innovation-intensive products, and therefore that the data can be used to test the extent to which different sector classifications reflect these characteristics.

3.1. Price performance reflects technology-, innovation- and knowledge-intensity.

Broadly speaking, the results of the sectoral investigation is as follows:

- In the case of Davies and Lyons' classification, there is a substantive difference between those sectors which are advertising and R&D intensive and other sectors which either have no quality focus, or are only R&D intensive. This would seem to confirm the basic hypothesis that price behaviour reflects innovation/knowledge intensity.

- Neven provides a complex, multi-faceted classificatory system. The two sectoral categories which stand out as being less susceptible to price declines are the high-tech/high human capital and the human capital/investment intensive sectors. An interesting result of this analysis is that there was little difference in the susceptibility towards price-decline between the labour-intensive and the labour-/capital-intensive sectors; as Neven points out, in the contemporary world of high liquidity, capital is almost as widely available as labour (a similar assumption underlies Wood's widely-cited analysis of the employment effects of global trade – Wood, 1994)

- The UNCTAD technology-schema shows little differences between the different classifications. However its more recent category of dynamically-traded products does not suggest that these products are less susceptible to falling unit prices. (In fact the opposite might be expected, with growing trade being associated with falling prices; but there is no evidence of this either).

- Using the OECD classificatory system, there is evidence to suggest that the medium-high and the high tech sectors are least susceptible to price fall.

- Lall's classificatory system shows that the high-tech sectors are relatively unaffected by price-pressures; what is interesting from his analysis is that the low- tech and engineering sectors are more affected by falling prices, no doubt reflecting the growing participation of new entrants (notably China) during the 1990s.

- Perhaps surprisingly, the Complex Production System products show no particular tendency to resist pricing pressures; however the one-off, customised nature of these products makes it less likely that the products traded during this period will be easily comparable.

- Sutton's R&D intensive sub-sectors are relatively unaffected by falling prices, confirming the conclusions arising from Davies and Lyons' related categories.

Table 2: Unit price behaviour, 1988-2001*

Sector	***Total***	***Positive slopes***		***Negative slopes***	
		Number	**%**	**Number**	**%**
Davies and Lyons					
Total	571	235	41	336	59
No quality focus	297	93	31	204	69
R&D Intensive	275	112	41	163	59
Advertising Intensive	6	4	67	2	33
R&D and Advertising Intensive	84	44	52	40	48
Neven					
Total	1,904	719	38	1,185	62
High-tech, high human capital	585	263	45	322	55
High human capital low invest	907	357	39	550	61
Labour intensive	406	136	33	270	67
Labour and capital intensive	424	139	33	285	67
Human capital and invest intensive	6	4	67	2	33
UNCTAD					
Total	3,632	1,287	35	2,345	65
Labour/resource intensive	1,118	343	31	775	69
Low-skill/low-tech/low capital intensive	430	142	33	288	67
Medium-skill/medium-tech/medium capital intensive	738	264	36	474	64
High-skill/high-tech/high capital intensive	1,043	432	41	611	59
OECD					
Total	3,816	1,297	34	2,519	66
Low	1,215	362	30	853	70
Medium low	767	204	27	563	73
Medium high	1,451	544	37	907	63
High	384	188	49	196	51
Lall					
Total	2,006	737	37	1,269	63
Resource-based	472	185	39	287	61
Low technology	674	196	29	478	71
Medium technology	295	120	41	175	59
Engineering	336	111	33	225	67
High technology	245	119	49	126	51
COPS (4-digit)					
Manufacturing	69	29	42	40	58
UNCTAD					
Dynamic products	322	141	44	181	56
SUTTON					
R&D Intensive	144	71	49	73	51

In summary, we believe that it is fair to conclude that despite the differences in the classificatory systems utilised and despite ambiguities within and between these classifications, the evidence would seem to bear out the hypothesis that the more technology- and knowledge-intensive the sector, the less likely it is that unit-prices will fall.

3.2. How does the data illuminate sectoral classifications?

If it is assumed that price behaviour reflects technology-, innovation- and knowledge-intensity, the results in Table 2 can be sued to interrogate the robustness of various sectoral classifications aiming to address these elements of factor-intensity. The main conclusions which can be drawn are as follows:

- Davies and Lyons show the importance of a combination of process (R&D) and product (advertising) intensity. The small number of advertising- (but not R&D-) intensive sectors makes it difficult to support what looks likely to be an especially strong association between branding and price performance, although there are strong a priori reasons to suppose that brand-intensive products are relatively immune from price pressure.

- Neven presents a complex amalgam of sectors. The only category which seems relatively immune from price pressure is one with very low sectoral representation, that is human capital/investment intensive; however, the four-digit analysis (which due to data unevenness in the COMEXT dataset) provides data on 13 sub-sectors in this category (out of a total of 746 sub-sectors) and this, too, shows a lower incidence of price decline (46 percent).

- The UNCTAD classification shows little difference between the price performance of the individual categories, bar that for the high-skill/high-tech/high-capital intensive group, a similar conclusion to that of Neven.

- The OECD classification seems to provide supportive results for the medium-high and high-tech categories; but the medium-low technology group performs in a similar nature to the low-tech group.

- Lall's classification is probably most clearly supported by the data. There is a clearly a smaller tendency for prices to fall the greater the technology-intensity; the engineering industries reflect a particular subset of competitively-traded goods and do not necessarily align with technology intensity. Interestingly, the data suggests that the resource-intensive sectors are subject to a somewhat lower degree of price competition.

- Although the COPS category is made-up of a number of knowledge-intensive one-off products, this does not appear to be reflected in this sector's price performance

- Sutton's widely-used R&D intensive classification is supported by the data; however it does not appear to corroborate the R&D intensive classification provided by Davies and Lyons.

4. Discussion and Conclusions

In this paper we have examined the links between price performance in globally-traded goods and technology- and innovation-intensity. Assuming away the problem of cost-reducing productivity change and differential “vertical disintegration of trade” (Hummels et. al., 1998) (heroic assumptions perhaps, but no more heroic than those made in studies which measure innovation through either input or output indicators), this is a logical step in neo-Schumpeterian analysis. The results arising from the examination of unit-price trends in more than 12,000 different sub-sectors provides qualified support both for the primary hypothesis underlying this paper and for some of the received classifications of technology-innovation and knowledge-intensity. We can therefore conclude that the analysis of unit-price performance is a valid technique to be used in innovation studies, in concert with other similarly-flawed measures such as R&D intensity and patenting activity. (We have placed the data on our website – www.ids.ac.uk/global/ - so that they can be more widely used).

In undertaking this analysis we have surveyed 23 different sectoral classifications. We have two primary concerns about these received taxonomies. First, in most cases they are based on dated economic structures even though we have deliberately excluded some of those such as the classic and frequently-cited study by Leamer which relies on pre-1973 data on economic structures (and which to our surprise – shock? - is still used in contemporary classifications). And, second, they are almost all based on aggregative two-digit and three-digit data.

In response to these weaknesses, rather than replicating the static price analysis found in much of the literature (Celi and Smith, 2003; Schott, 2002; Aiginger, 2000), we have focused on changes in prices. However, the short duration of the COMEXT data-base (1988-2002, albeit with monthly data) makes it difficult for any acceptable statistical technique to verify price-trends, and for this reason we have only calculated average unit price trends. In addition, we have given primacy to sectoral disaggregation, widening the two- and three-digit classifications used in received studies to six-digits. Our complementary analysis of unit-price trends (using a larger number of sectors than those involved in this paper on innovation-intensive sectors) shows that the higher the degree of disaggregation, the greater the incidence of price trends (Kaplinsky and Santos-Paulino, 2004), a conclusion corroborated by Celi and Smith (Celi and Smith, 2003).

The major analytical conclusion which arises from this research is the need to push forward classificatory systems to both embody greater detail and more recent structural relationships. Of all the 23 classifications which we have examined, only Lall’s begins to meet these challenges. However, as can be seen from Table 1, Lall’s classification is based on the author’s judgement, and whilst his expertise is considerable, it is a poor substitute for the use of measured structural relationships to define different sectors. Can we make further progress on this front? There are two possible data-sets which we have identified which hold promise, and which provide the capacity for the integration required to provide a comprehensive picture of sectoral dynamics. The first is Office of National Statistics Annual Business Survey covering 78,500 enterprises and conducted most recently to cover the years 1997-

2001.[6] The second are the various Community Innovation Surveys conducted in various EU economies which are based on the Oslo Manual. These data-sets are not ideal, since the level of detail they provide only allows two- and perhaps three-digit data-analysis. However, their recent vintage means that they will provide an opportunity to update the structural relationships in the various received classificatory systems reviewed in Table 1. They also provide a combination of input- and output-based innovation indicators, including the use of ICT and advertising and marketing intensity.

But what of the policy conclusions which stem from our analysis? Again, assuming away the problem of differential productivity change and value-added thinning between sectors, and therefore assuming that unit-price performance reflects the income streams associated with global trade, there are clear conclusions which arise from the data. First, brand-intensity – despite the small sample in the Davies and Lyons analysis – is probably an important signifier of sustainable income, a conclusion which is corroborated in the growing volume of value chain literature (Gereffi and Kaplinsky, 2001; Gereffi, Humphrey and Sturgeon, 2004). Second, the lower the technological content in products – reflected in a range of measures – the more likely that price pressure will be felt. And, third, perhaps surprisingly to some, resource-intensive sectors may not be under as much relative price-pressure as has been assumed in much of the literature on terms of trade and industrialisation, since the growing presence of China in world trade of manufactures has become manifest.

These conclusions are relevant to the corporate sector, although for some time the corporate sector has been implementing appropriate strategies, particularly those firms based in the high-wage economies. But more pertinently, the conclusions need to be absorbed by public policy actors in low-wage economies, and by the industry of consultants and multi-lateral and bi-lateral agencies who advise (and perhaps more often "guide") resource allocation in low wage economies. For example, the World Bank's definitive statement of its position on globalisation in 2002, concluded that the exports of labour-intensive and low-technology manufactures has been the major factor in allowing developing countries to grow rapidly and to alleviate poverty (World Bank, 2002). Whilst the analysis of export prices alone does not allow this conclusion to be definitively questioned, it does suggest that there may be a fallacy of composition in this policy prescription (Mayer, 2002). Maizels' two-digit studies of the falling terms of trade between developing countries and the EU, the US and Japan (Maizels et al, 1998 and 1999; Maizels, 2003) supports this cautionary conclusion.

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[6] For a discussion of the ABI, see Jones 1990

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