The role of technology in market shares dynamics

BRUNO AMABLE and BART VERSPAGEN

INRA, 65 Boulevard de Brandebourg, 94205 Iry Cedex, France and MERIT, PO Box 616, 6200-MD Maastricht, The Netherlands

The paper presents the estimation of an empirical model of market share dynamics for five industrialized countries and 18 industries. The emphasis is put on the importance of non-price factors of competitiveness, whereas most traditional explanations rest on the influence of relative prices. Among the former type of factor, the role of variables reflecting technological advantage is privileged. In particular, the role of innovations has received considerable attention in the literature on international trade as well as the literature on endogenous growth. In this spirit, the paper introduces patent counts and investment as explanatory variables for the export-market share. The results show that non-price variables have an important impact on the determination of long-run competitiveness.

1 INTRODUCTION

The relationship between technology and competitiveness has recently become a major topic for both theoretical and empirical analyses, and has also aroused the interest of political decision makers (Clinton and Gore, 1993). Strictly speaking, traditional neoclassical trade theory hardly took into account differences in technological performance in explaining trade flows between countries, supposing that every country had access to the same technology set and concentrating on factor endowments, and hence on factor prices, instead. However, it is known that testing 'traditional' trade equations (i.e. with income and prices as explanatory variables) often leads to weak price effects, when significant. In most cases, it seems hard to relate changes in competitiveness precisely to price differentials. Some other influences, not directly related to the price of traded goods, are at work.

Some authors have stressed the importance of non-price factors in international competition particularly in connection with technological changes. On the neoclassical side, the various works of the 'new international economics', with authors such as Krugman (1990), insist on product differentiation and increasing returns to scale on the supply side, and preference for variety on the demand side rather than on factor endowments. Innovation leads to the generation of new products, and R&D expenditures are a strategic variable manipulated by firms to secure monopoly positions. R&D and trade specialization also play a role in economic growth when we consider endogenous growth models in an open economy context (Grossman and Helpman, 1991). Comparative advantage may become endogenous, and trade and research policy measures can have an effect on trade specialization and growth rates.

Related themes are present in the post-Keynesian literature (Thirlwall, 1979; Kaldor, 1981), where the emphasis lies on non-price factors of competitiveness (Amable, 1992). Neotechnologies (Soete, 1987) or 'evolutionary' approaches to technological change and growth (Dosi et al., 1990; Amendola et al., 1993; Verspagen, 1993) also stress that international technological differences can provide a basis for trade, which is treated as a dynamic process of competition.

The aim of this paper is to provide an empirical study of the determinants of exports market shares at a disaggregated level, taking account of international differences in technological performance and other non-price factors. The paper is organized as follows. Section II reviews the price and non-price factors behind international competitiveness. Section III proposes an empirical model of exports-market shares incorporating both price and non-price effects. The estimation of the model is carried out on 18 industries for
five industrialized countries over a period of 22 years. The specification of the model is inspired by Magnier and Toujas-Bernatte (1992). It accounts for both country- and industry-specific effects for each explanatory variable, and for country-specific effects on the dynamic adjustment term. Results are presented in Section IV. In Section V, a comparison is made between the results of the estimations and the sectoral taxonomy found in Pavitt (1984) and Dosi et al. (1990), which is based among other things on the importance of various modes of competition and the pattern of technological change.

II. PRICE AND NON-PRICE FACTORS OF COMPETITIVENESS

Many applied studies have incorporated non-price factors along with price factors in foreign trade modelling. To recall, a common approach to modelling trade flows takes price and income differentials as explanatory variables (Goldstein and Khan, 1985). A typical equation incorporating such effects would be of the following form:

\[ X = Y^* \left( \frac{P}{P^*} \right)^\eta \]  

(1)

where \( X \) and \( P \) are the country’s exports and price level, and \( Y \) and \( P^* \) are the income and price level of the rest of the world. Imperfect substitutability, and hence imperfect competition, between goods allows for the existence of non-infinite price elasticities \( \epsilon \), so that the law of one price does not hold. A country’s exports are then more or less sensitive to price differentials according to the value of \( \epsilon \). Sensitivity to price variations depends very much on the type of goods exported, so that we would expect different price elasticities according to the industry of origin of the exported goods. The value of a country’s price elasticity of exports therefore reflects to some extent the product mix of the country’s exports.

Price differences are the most obvious influences of trade competitiveness. Nevertheless, the ‘Kaldor paradox’ (Kaldor, 1978) comes from the observation that the fastest growing countries in terms of GPD and exports have experienced a faster growth in relative unit labour costs. Therefore relative prices, when taken alone, cannot be the major determinants of competitiveness. In the long term a country cannot expect to see its exports growing because of a continuous decrease in relative prices. The post-Keynesian explanation of growth in an open economy framework relies mostly on the ‘Thirlwall formula’, i.e. the ratio between the export and import income elasticities. Competitiveness and growth in the long run depend on non-price factors alone.

Influences other than price competitiveness are then summed up in the income elasticities of imports and exports. A higher \( \eta \) means that all other things being held equal, a country will benefit more than others from the growth of world income. Several interpretations of \( \eta \) may be related to a high \( \eta \) (McCombie, 1992; Amable, 1993). It may reflect the sectoral orientation of the country’s exports. Some industries enjoy a higher income elasticity because their products tend to be substituted for the products of other industries as income rises. For instance, high-technology goods generally have a higher than average demand growth. The value of the elasticity may also reflect the quality of the exported goods. \textit{Ceteris paribus} countries with high-quality products will gain market shares over other countries. All in all, the income elasticity usually represents the bulk of non-price factors. It has also been used as an indicator for industrial policy. In Japan, for instance, a MITI white paper recommended in the 1960s reorienting the international specialization of Japan towards industries with a high rate of productivity growth and a high income elasticity (Itoh and Kiyono, 1988).

In such a perspective, an explanation of what determines non-price competitiveness is lacking, since income elasticities are given exogenously in theoretical models of foreign trade and estimated directly in applied works.\(^4\) It is then possible to introduce additional factors in trade equations such as Equation 1. Introducing a broad ‘Schumpeterian’ aspect, one can think of differences in technological capability as one of the main influences behind non-price competitiveness. Hughes (1986) proposed a model for the exports of the UK where factors in the form of relative R&D expenditures represented non-price effects. The model also took account of cumulative causation through the influence of exports on R&D intensity. Fagerberg (1988) proposed a multi-equation model including a technology variable constructed with patent counts and R&D expenditure. Trade equations also took into account the effects of investment in order to reflect the international differences in the ability to meet demand and escape from capacity constraints. A multi-equation model of growth and competitiveness is tested in Amable and Boyer (1992), with an endogenous determination of technological change in addition, on a sample of eight industrialized countries over the period 1961–87. Greenhalgh (1990) tested trade equations on time series with a product-quality variable, quality being a function of technological innovation and supply reliability. The former is represented by the number of innovations taken from the SPRU innovation database and the latter by strike incidence. In an evolutionary spirit, Verspagen (1993) tested several models of competitiveness with variables reflecting price as well as technological competitiveness.

Neoclassical supply-side explanations may also account for the role of technology in trade. Magnier and Toujas-

---

\(^3\)See McCombie (1992) for an exposition of ‘Thirlwall’s law’ as well as the debate on it.

\(^4\)The value of the income elasticity may change over time, reflecting improvements or worsening of a country in non-price competitiveness (Landesmann and Snell, 1989).
Bernatte (1992), making reference to the 'new international economics', considered that countries can expand their world market shares by expanding the range of goods that they produce. New goods being discovered with the help of R&D expenditures, they introduced an R&D variable in their trade equations, along with an investment term, reflecting the ability to deliver. Exports-market shares are thus related to the share of each country in OECD's R&D expenditures. While not confining itself to their theoretical references, this paper will adapt the dynamic-adjustment model of Magnier and Toujas-Bernatte to provide an estimation of non-price effects on international competitiveness.

III. A MODEL OF INTERNATIONAL COMPETITIVENESS

The empirical model will be tested on pooled time series and cross-section data for five industrialized countries (Germany, Italy, the UK, Japan and the USA) and 18 industries over the period 1970–91. The industry disaggregation is given by the STAN (OECD, DSTI) database. Although 12 countries are present in the database, data availability has restricted the set of countries to five. Three factors of competitiveness will be considered: price, investment and technology. Following Magnier and Toujas-Bernatte, it will not be assumed that the same coefficients apply to every country and every sector of the sample. Since the sample covers the whole manufacturing industry, some sectors are likely to be more sensitive than others to technological advantage, to price differentials or to investment. We may, for instance, expect technology intensive sectors to be more dependent on the technology variable than other sectors.

Similarly, countries specificities will be taken into account. In the post-Keynesian explanation of growth in the context of an open economy, the differences in a country's ability to be technologically competitive are summed up in differences in the values for the income elasticities of trade. The determinations of these elasticities implicitly includes both industry- and country-specific influences. The latter are interpreted as reflecting unequal competitiveness related to the particularities of the national systems of innovation (Freeman, 1987). Several factors, related to the accumulation of individual competence and the mechanisms of collective learning, come into play: the efficiency of the education system, the quality of intra- and interfirm-cooperation, infrastructure policy, the relations between firms and the public authority, etc. Industry differences with respect to technology or non-price influences in general are more widely recognized. Some industries (or rather the goods produced by these industries) are held to be more ‘mature’ than others in the product-life-cycle theory. Some industries are more sensitive to the competition of less advanced countries that tend to base their competitiveness on low wage costs. More generally, the technological content varies widely across industries and thus sensitivity to technological competitiveness is also expected to vary.

Therefore, the coefficients of the model will be both country and industry specific, but the coefficients will not be specific to each pair of country and industry. In fact, the differences between countries are assumed to be the same across industries, and the differences across industries are assumed to be the same across countries. A higher elasticity is therefore attached to a particular industry, whatever the country. The coefficients of the explanatory variables are therefore the sum of an average effect, a country effect and an industry-specific effect.

The determination of the long-run value of the market share is the following:

\[ X^*_i = k_{ij} + a_{ij}PC_{ij} + b_{ij}IN_{ij} + c_{ij}PT_{ij} \]  (2)

and \( x_{ij} = x_i + x_j \). \( \Sigma x_i = x_j = 0 \) for country \( i \) and sector \( j \), \( x = a, b, c \).

Three types of determinants influence the long-run market share of each country for each sector: price, investment and technology. The first factor in the equation, \( PC \), reflects the influence of price competitiveness. It was not possible to obtain price indices at the level of disaggregation adopted in this paper from the STAN (OECD) database. Therefore, a measure of relative unit labour cost is used, which is defined as the wage sum (in current US$) divided by value added in 1985 price (also US$). As with other variables, this variable is expressed relative to the industry average for all countries in the sample.

The second variable, \( IN \), is the ratio of investment to production divided by the average value of this ratio for all countries. This variable accounts for non-price factors not directly related to technological innovation as measured by the patenting variable (discussed below). For instance, learning effects or the accumulation of competences can be thought to be represented in this variable, but so also are effects related to embodiment of innovations in new capital.

The introduction of variables reflecting the influence of

---

5 This point is developed in Amable (1992).
7 Data on constant price value added at the three-digit level, ISIC-level, and within 384, at the four-digit level was kindly supplied to us by Andrew Wyckoff, OECD. Note that our sample includes four-digit sectors for which no constant price value added was available (drugs and medicines, computers and office machines, electronics). For these sectors, we used the corresponding three-digit (implicit) price indices for calculating constant price value added. For computers and office machines (3825), price indices are also given in Wyckoff (1993). However, due to the methodological difficulties noted by Wyckoff (1993), we restricted the use of these data to an experiment in which we used the US (hedonic) price index as the assumed world price, and deflated value added in 3825 by this index in all countries. The results of this experiment were similar to the estimations reported below, and are available from the authors on request.
these factors more directly would have been preferable, but data availability restricted the choice.

PT, the technological variable, is defined as the share of each country in the total patents for each sector relative to the mean of all countries' shares. It represents the direct effect of innovation on competitiveness. Following most authors dealing with patent counts, patents granted in USA are used and a fractional count is adopted. This means that if a patent is common to several sectors, it is supposed that it benefits each sector, so that the patent is equally 'split' between these sectors.

In order to erase very short-term aspects, explanatory variables considered in the model are smoothed by averaging. Since the time series used are not that long, the number of lags is limited to three years and a 'bell-shaped' effect is adopted:

$$A = \left( A(-1) \right)^6 \left( A(-2) \right)^6 \left( A(-3) \right)^6$$

for $A = PC, IN, PT$. All variables are taken in log and in difference with respect to the sample average for the industry considered. All variables are taken from OECD, DSTI (STAN/industrial database) except for the patent data which come from the USPTO database.

The basic model is based on an error correction mechanism:

$$\Delta X_{ij} = (\mu + \mu_i) [X_{ij}^* - X_{ij}(1)]$$

for $X_{ij}$, the current exports (OECD) market share of country $i$ for sector $j$, adjusts more or less slowly to $X_{ij}^*$, the long-run target market share defined in Equation 2. The adjustment coefficients are country specific, with the restriction that $\Sigma \mu_i = 0$.

The model is similar to that of Magnier and Toujas-Bernatte (1992) with a few differences: (1) the dynamic adjustment coefficients are country specific, i.e. the sum of an average $\mu$ and a country-specific effect $\mu_i$, so that countries may adjust to their long-run targets at their own pace; (2) these coefficients are estimated and not assigned a specific value, therefore the estimation is made with non-linear least squares; (3) the technology variable makes use of patents data, not of R&D expenditures. Patents have the advantage of representing an output of an innovation process; but this does not imply that this is the only possible variable. Both R&D expenditures and patent counts have their faults as indicators of technological competitiveness. Some R&D-intensive industries patent very little, whereas other industries patent a great deal. There are also international differences between the tendency to patent. It would, of course, be possible to compute a specific indicator mixing patents with R&D., as in Fagerberg (1988), but this raises the problem of the basis on which it would be computed. Limiting ourselves to innovations leading to a legal protection, we here adopt a patent-based indicator. This model does not take account of the technological spill overs between sectors or between countries. Each country and industry's competitiveness is based on the own-country and sector's factor of competitiveness. The investigation of such spill over effects is left for further research.

The estimation of the model is carried out with variables taken as log deviations from the sample's average for each sector. The estimations are made with non-linear least squares and are heteroscedasticity consistent.

**IV. ESTIMATION RESULTS**

This section reports the results of the estimation of the model presented above. The expectations for the signs of the variables are as follows. For patenting and investment variables, a positive sign is expected since these variables represent the positive factors affecting non-price competitiveness. For relative unit labour cost, the expected signs on the estimated parameters are little ambiguous. From the point of view of production costs, we would expect high wages to lead to low relative competitiveness, and hence that the parameters would be negative in the estimation. However, as high wages might also be connected to high skill levels, low wages might also be connected to low competitiveness. It may therefore be the case that the exact expectation on the sign of the wage variable differs between sectors. In sectors with high-skill requirements, the sign might be positive, while in sectors where labour input has a low-skill level, the sign is expected to be negative. Nevertheless, since each variable is compared to averages, the general expectation is a negative sign.

The expectations concerning the results for the adjustment coefficients (specific to countries) do not result in any clear way from the theoretical framework put forward above. This framework is intended to explain the relationship between long-run competitiveness and various factors such as wages, investment and technology. A dynamic adjustment model was thus specified, taking account of the fact that a country can adjust only slowly to the position defined by Equation 2. On the other hand, the

---

8 The use of patents data is very common in studies of innovation (e.g. Soete, 1987). The largest patenting system is the US system. It is held by most scholars of technical change as the most representative patenting system, by contrast with national patenting systems, which embody many country-specific aspects which would make an international comparison difficult. The share of foreign firms in total US patents is roughly 55% (1991). Besides, the only system where data are available for our industry disaggregation and time period is the US system.

9 The specific choice of the weights is of course highly arbitrary, but the commonly held view is that they do serve as an approximation for the actual lag structure. The values adopted here are the same as in Magnier and Toujas-Bernatte (1992). For a similar method, and similar values, see, e.g. Patel and Soete (1985).
process of adjustment has not been precisely specified, and countries' characteristics in this respect are summed up in the adjustment terms. These characteristics are related to the particularities of the national institutional arrangements, such as trade-policy measures, wage-bargaining procedures or macroeconomic influences affecting the exporting countries.

The results for the estimation are documented in Table 1. The country-specific adjustment parameters are all very significant and positive. Germany and the USA both have relatively low values (around 0.3), the UK and Italy exhibit higher values of this coefficient (around 0.4). Japan seems characterized by a very high adjustment coefficient (0.8), well above the values of the other sample countries. In fact, Japan exhibits a quasi-instantaneous adjustment to the long-run market shares. This indicates that the general institutional arrangements in Japan may substantially differ from those of Germany, the USA, the UK or Italy.

Moving to the average effects per variable, it appears that wages and patents have the expected sign (negative for wages, positive for patents) that is significant. The investment–output ratio has a positive sign, as expected, but is not significant. This pattern is more or less repeated for the case of the country-specific effects per variable. For unit

<table>
<thead>
<tr>
<th>Table 1. Estimation results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Regression statistics: SD of dep var = 0.119 SE of the regression = 0.103 Adj. $R^2$ = 0.25</td>
</tr>
<tr>
<td>Adjustment parameters</td>
</tr>
<tr>
<td><strong>μ</strong></td>
</tr>
<tr>
<td><strong>μ + μ_c</strong></td>
</tr>
<tr>
<td><strong>DEU</strong></td>
</tr>
<tr>
<td><strong>GBR</strong></td>
</tr>
<tr>
<td><strong>ITA</strong></td>
</tr>
<tr>
<td><strong>JPN</strong></td>
</tr>
<tr>
<td><strong>USA</strong></td>
</tr>
<tr>
<td>Average effects per variable</td>
</tr>
<tr>
<td><strong>Estimate</strong></td>
</tr>
<tr>
<td>Unit labour costs</td>
</tr>
<tr>
<td>Investment</td>
</tr>
<tr>
<td>Patents</td>
</tr>
<tr>
<td>Country effects</td>
</tr>
<tr>
<td>Long-run effects per country (sum of the average effects and the country specific effect)</td>
</tr>
<tr>
<td><strong>DEU</strong></td>
</tr>
<tr>
<td><strong>GBR</strong></td>
</tr>
<tr>
<td><strong>ITA</strong></td>
</tr>
<tr>
<td><strong>JPN</strong></td>
</tr>
<tr>
<td><strong>USA</strong></td>
</tr>
<tr>
<td><strong>Wages</strong></td>
</tr>
<tr>
<td><strong>p-value</strong></td>
</tr>
<tr>
<td>Aerospace</td>
</tr>
<tr>
<td>Chemicals</td>
</tr>
<tr>
<td>Drugs and medicines</td>
</tr>
<tr>
<td>Electronics</td>
</tr>
<tr>
<td>Electrical machinery</td>
</tr>
<tr>
<td>Instruments</td>
</tr>
<tr>
<td>Non-electrical machinery</td>
</tr>
<tr>
<td>Computers and office machinery</td>
</tr>
<tr>
<td>Food products</td>
</tr>
<tr>
<td>Rubber and plastic</td>
</tr>
<tr>
<td>Textiles</td>
</tr>
<tr>
<td>Metal products</td>
</tr>
<tr>
<td>Ferrous metals</td>
</tr>
<tr>
<td>Non-ferrous metals</td>
</tr>
<tr>
<td>Stone, clay, glass</td>
</tr>
<tr>
<td>Shipbuilding</td>
</tr>
<tr>
<td>Motor vehicles</td>
</tr>
<tr>
<td>Other transport</td>
</tr>
</tbody>
</table>
labour cost, four coefficients are significant: those for the UK, Italy, Japan and the USA. All signs for this variable are negative, as expected. It should be noted that the Italian coefficient is lower than the coefficients of the other countries. For investment coefficients, a significant positive sign is obtained only for Japan. For patents, there are four positive and significant parameters (UK, Italy, Japan and the USA), and one negative but insignificant effect (Germany). In the latter case, it is important to keep in mind that since the patent data set used applied to patents taken out in the USA, one might expect a bias for American firms to patent more than proportionally (see among others Dosi et al., 1990). This would lead to the expectation that the estimated coefficient for the US-specific patenting effect would be relatively small as compared to the other countries. The results, however, indicate the opposite. Apart from the other influences, patenting, and thus innovation, has a larger impact on the dynamics of market shares in the USA than in the other countries.

The results for sector-specific effects per variable are now discussed. For unit labour costs, 16 out of 18 estimated coefficients are negative. Eight of these 15 are significant at a level smaller than 10%, and two have a significance level between 10 and 15%. The significant and negative parameters are found in the following sectors: chemicals; instruments; food products; rubber and plastic; textiles; metal products; ferrous metals; and stone, glass and clay. Two sectors have a positive sign, none of the coefficients being significant. It thus turns out that the unit labour cost variable has a significant (negative) influence in a quite broad range of sectors, including low-tech (and homogeneous products) sectors such as textiles and metal products, but also high- and medium-tech sectors, such as instruments or chemicals, and possibly electronics.

For investment, there are eight sectors with a positive coefficient. Two of these are significant at the 10% level: aerospace; and computers and office machinery. Two others, chemicals and instruments, are significant at the 15% level. Two sectors, stone, glass and clay and motor vehicles, have significantly negative coefficients. While the performance of this variable is not as good as the previous one (in terms of significant results), it is quite remarkable that the majority of sectors for which a significant positive influence is found to have a high technology-content.

The results for the patent variable are quite good: 11 sectors have a significantly positive sign at the 10% level, one has a significantly positive sign at the 15% level, while the six others have a positive but insignificant, sign. Two of the latter sectors, however, are sectors which are commonly ranked as high-tech: electronics and aerospace. Thus, while the patenting results seem to be quite good overall, showing the importance of technological competitiveness in a broad range of industries, they are somewhat difficult to interpret for a few of the high-tech sectors. The other high-tech industries (drugs and medicines, instruments, computers and office machinery) have quite high values of the estimated coefficients.

In general, these results point to the conclusion that technological change is an important determinant of international competitiveness. This conclusion is based upon the results for the patenting variable, representing the effects of innovation, as well as (some of) the results for the investment variable, which represent the effects of new capital equipment. Labour costs (i.e. production costs) are also important for competitiveness. Thus, it appears that price as well as non-price factors are important determinants of international competitiveness. An analysis omitting either of these two factors is therefore likely to suffer from a bias due to misspecification.

However, there seem to be important differences between sectors, as well as countries, with regard to the importance of the factors in the regressions. As far as differences between countries are concerned, the paper will not discuss these in further detail. They are just taken as implications of the (institutional, structural) differences between countries in the samples. The sectoral differences, however, will be the basis for some further discussion.

V. INTERPRETING THE SECTORAL DIFFERENCES IN THE ESTIMATIONS

The discussion of the theory of international trade related to price and non-price factors has already mentioned the fact that different sectors can be expected to show different patterns with regard to the determination of competitiveness. This conclusion links up closely with some of the work with a more institutional background. For example, Dosi et al. (1990) and Pavitt (1984) have proposed a sectoral taxonomy based upon an in-depth study of technological activities. After a review of the literature on differences in sectoral patterns of technical change, they propose a trichotomy of sectors.

Although the formal statistical analysis in this paper cannot compete as regards the richness of details with the institutional approach from which this taxonomy arises, it might be useful to interpret the results obtained from the estimations in light of this taxonomy. The way to do this is to compare the significance and values of the estimated sectoral coefficients between the three groups of sectors, and discuss whether or not the results from the estimation confirm expectations formed on the basis of the taxonomy. The three groups of sectors, their characterization and expected signs of variables are as follows.

First, there are supplier-dominated sectors. Firms in these sectors rely mostly on suppliers of materials and equipment for the development of new technology. Process innovation is more important than product innovation, and price competition is important. Dosi et al. (1990) mention textiles, printing and publishing, agriculture and construction as
supplier-dominated sectors. In terms of the aggregation logic used here, this group would include food products and textiles. Expectations for signs in this group would be that wage-costs are significantly negative, and play a large role. Other variables (patents, investment) are not expected to be very important.

The second group of sectors is called production intensive. In these sectors, production is organized according to Adam Smith's principle of the division of labour, or in more modern terms, Taylorism. Scale economies and the availability of sophisticated machinery are important in these sectors. Innovation is mainly of the process type. The main source of innovation is specialized supplier firms. Standard materials, durable consumer goods, instruments, machinery and automobiles are found in this category. In terms of the sectors used in this paper, this translates into instruments; non-electrical machinery; rubber and plastic; metal products; ferrous metals; non-ferrous metals; stone, clay, glass, shipbuilding; motor vehicles, other transport. With regard to the variables, the prime variable here would be investment, indicating the scale sensitivity. Wage and patenting variables might also play a role, however, but to a more limited extent.

The third group of sectors is called science based. The main source of innovation in these sectors is their own R&D, and innovation is mainly of the product type. New products, which in most cases applied in other industries, are the most important mode of competition in these sectors. Chemicals, electrical goods and electronics are found here. In terms of the sectors in the present analysis, this would include aerospace; chemicals; drugs and medicines; electronics; electrical machinery; computers and office machinery. The patent variable is expected to play a large role in this group, along with a possibly minor role for the investment variable.

Let us now look at the estimation results again, and confront them with the expectations formed above on the basis of the sectoral taxonomy. With regard to wages, it appears that the two supplier-dominated sectors (textiles and food products) are ranked at positions one and two in terms of the absolute size of the parameter on the wage variable (out of 15 sectors with a negative sign). The production-intensive sectors are ranked lower. While the results for these two groups of sectors are in broad accordance with expectations, it is surprising to see that some of the science-based sectors (aerospace, electronics, chemicals, electrical machinery) rank relatively high with respect to the absolute size of the wage variable.

Turning to the non-price factors in the regression, the results for the investment variable are discussed first. Although the results for this variable are not very strong, they seem to point out that investment is especially important in science-based sectors (aerospace, chemicals, computers), which was to some extent expected. However, the production-intensive sectors do not behave according to the expectations, i.e. the parameters are mostly insignificant, and often have the wrong sign. In fact, the only sector in this group, instruments, seems to be a borderline case between production-intensive and science-based sectors.

Turning finally to the patenting variable, the results again support expectations, it is important to note that patents have been attributed to ISIC classes on the basis of the principle of the 'sectors of origin', e.g. a wood-working machine is classified in machinery rather than wood products. This is important, since the taxonomy introduced above is based to an important extent on user-producer relations in the field of technical change. The science-based sectors, indeed, have a number of significantly positive signs on the patent variable. Some of these (chemicals, computers and office machinery, electrical machinery) also rank high in terms of the size of the parameter. However, it is notable that the importance of patents is much broader than just the science-based sectors. In fact, the two supplier-dominated sectors (food products and textiles) show significantly positive signs, and so do most of the production-intensive sectors. For the latter category, this is not so surprising in the case of, for example, machinery and instruments, since these sectors are the 'supplying' ones inside the broad cluster of interrelated sectors. For others, like basic metals or stone, clay and glass, the results are more surprising on the basis of a priori expectations from the taxonomy. The conclusion of this comparison between the sectoral taxonomy and the results obtained above is therefore two-fold. First, there are a number of cases where the results seem to support the taxonomy proposed by Dosi et al. (1990) and Pavitt (1984). However, there are also a number of cases where the results seem to indicate that the proposed differences between sectors are much too sharp to be reproduced in a formal test of the determinants of competitiveness. This latter argument relates primarily to the non-price factors in the determination of international trade (investment and patenting). To some extent, this conclusion is probably the result of the problems connected to the approach adopted (lack of detail and ability to account for specific institutional factors). However, the general character of the test and its outcomes also seem to indicate the limited usefulness of the specific taxonomy outside the field of institutional economics.

VI. SUMMARY AND CONCLUSIONS

This paper has attempted to quantify the importance of price and non-price factors in the determination of international competitiveness. A dynamic model of exports market shares adapted from Magnier and Toujas-Bernatte (1992) has been applied to a data set consisting of OECD–export

---

10One could argue about whether or not instrument should be classified under this group. Dosi et al. (1990) do, however, place it here.
market shares, wages, investment and patenting for a sample of five industrialized countries over 22 years. The estimation results show that both price and non-price factors matter in the explanation of export markets shares.

The model that was used distinguishes between sectoral, country-specific and general effects in the determination of the influence of each independent variable. In general, it was found that this approach adds significantly to the explanatory power of the estimations. The results show that patents are an important factor in the majority of sectors and countries Wage costs are also important in most countries and about one-third of the sectors. Investment is the variable which is least significant, although it still plays a significant role in some sectors.

The sectoral differences in the estimation results were applied to a sectoral taxonomy proposed by Dosi et al. (1990) and Pavitt (1984). Since this taxonomy is (partly) based upon difference modes of competitiveness, it was expected that the results obtained would in some way correspond to the taxonomy. The outcome of this comparison was that for the distinction between price and non-price factors, the taxonomy and results obtained correspond reasonably well. However, for non-price factors, the correspondence was more problematic. This leads to the conclusion that there is still a need for a theory leading to a taxonomy that can be applied in a broader field than just the one inspired by ‘institutional economics’.

ACKNOWLEDGEMENTS

The authors wish to thank Erik Beelen for very helpful research assistance and Andrew Wyckoff for his advice on, and supply of the data. The research of Bart Verspagen has been made possible by a fellowship form the Royal Netherlands Academy of Arts and Sciences.

REFERENCES

Wyckoff, A (1993), The impact of computer prices on international comparisons of labour productivity, Technological Forecasting and Social Change, Forthcoming.