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UK Export Behaviour at the Firm Level

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ABSTRACT

We estimate Probit and truncated regression models that incorporate the key theoretical explanations of firm-level export activity for a panel of UK firms over the period 1988 to 2001. Results support the resource-based, human capital and technological innovation explanations of firm-level export activity. In addition, we find that the level of the Sterling-Dollar exchange rate has a significant impact on both the decision to export and the level of export intensity, although the volatility of the exchange rate is found to vary between industries.

1. INTRODUCTION

GOVERNMENTS FREQUENTLY PURSUE policies designed to promote exports. The economic justification for assisting firms to export is based on the view that exporting encourages domestic innovation, efficiency and economic growth. Recent initiatives adopted by the UK government, motivated by *Our Competitive Future* (Department of Trade and Industry, 1998), are consistent with this thinking and are designed to improve a range of productivity and competitiveness variables in order to increase participation of UK firms in international markets.[2] These policies raise the question of what factors are important for firms to enter and expand into export markets.

Influential studies of UK manufacturing firms by Wakelin (1998) and Bleaney and Wakelin (2002) find that technological innovation and firm size are the causal drivers of innovating firms becoming exporters, whereas greater efficiency is the main determinant for non-innovating firms. Using UK plant-level data, Roper and Love (2002) find that product innovation has a positive impact on both the probability and intensity of exporting, although innovating plants gain more of any industry-level technological spillovers. Studies of firm export behaviour in other countries have also emphasised the heterogeneity of firm characteristics, indicating significant differences between exporters and non-exporters (Roberts and Tybout, 1997; Sterlacchini, 2001; Basile, 2001; Bernard and Jensen, 1995, 1997a, 2004).[3]

In this paper we examine the determinants of export behaviour for a panel of UK firms over the period 1988 to 2001. We define export behaviour in a dual manner: as the probability to export and the intensity of exporting. This distinction is important because if a set of variables impact on these two types of export behaviour differently, then this would provide helpful information to any business or government in their decision making. Importantly, our study extends the range of variables that impact on export behaviour. We examine the impact of firm product diversification on export behaviour because empirical evidence indicates that multi-product firms have greater levels of proprietary assets than focused firms (see, for example, Montgomery, 1994). Proprietary assets such as managerial skills and marketing capabilities can be exploited in export markets and their availability may lower entry costs. In addition, we explore the role of firm director human capital. Recent survey evidence produced by Grant Thornton (2003) indicates that a major barrier facing UK firms attempting to sell overseas is lack of foreign market knowledge. It may be the case that firms that employ more talented directors are better equipped at entering and expanding into foreign markets. Finally, we investigate the role of exchange rates by creating a firm-specific exchange rate that utilises heterogeneity in the calendar accounts period of each firm. To date, exchange rates have been captured in firm-level export equations by time dummy variables, making it difficult to separate the impact of exchange rates from other macroeconomic variables. In contrast, our approach allows for a firm-specific response to price shocks.

The remainder of the paper is organised as follows. In section 2 we present a model of export activity which incorporates the probability and intensity of exporting. The data sets used in our analysis are introduced in section 3, where we also report the empirical results of our modelling exercises. The final section draws out some policy implications.

2. Model specification

We take an encompassing approach to the specification of the empirical model and allow heterogeneity in firm-level characteristics to determine differences in export activity between firms. Defining export activity, EXP_{it}, of firm i at time t, the model can be written as:

$$\mathrm{EXP}_{it} = \alpha + \beta \mathrm{X}_{it} + \varepsilon_{it} \qquad i = 1, 2, \ldots, N \tag{1}$$

where X_{it} is a vector of firm-level characteristics, β is a vector of parameters to be estimated and ε_{it} is an error term. The dependent variable is defined in a dual manner. For the decision to export, the dependent variable is specified as a binary variable, taking a value of unity if the firm exports and zero otherwise. For export intensity we employ the ratio of export sales to total sales.

When the dependent variable is binary, estimation can proceed by a Probit regression and the sign of estimated coefficients represent the impact of independent variables on the probability of exporting. When the dependent variable is defined as export intensity, OLS estimates will be biased and the appropriate procedure is to use a Tobit estimator since the dependent variable is bounded between zero and unity (Greene, 2003). However, Cragg (1971) has shown that the Tobit regression model imposes a sign restriction on the impact of each explanatory variable on the probability of exporting and export intensity. This restriction implies that the vector of parameters in eq. (1) is the same for the two export decisions. The validity of this restriction can be tested against the alternative unrestricted form using the procedure proposed by Fin and Schmidt (1984). Their approach involves estimating three separate equations: a truncated regression model for export intensity on exporters only and Tobit and Probit regression models on all firms for export intensity and probability respectively. The resulting likelihood ratio statistic, λ, is:

$$\lambda = -2\left[\ln L_T - \left(\ln L_P + \ln L_{TR}\right)\right] \tag{2}$$

where L_T is the likelihood for the Tobit model, L_P the likelihood for the Probit model and L_{TR} the likelihood of the truncated regression. We apply the test statistic in (2) to our firm-level export data.

2.1 The choice of explanatory variables

Table 1 presents a description of all variables included in the empirical modelling.[4] Firm size has traditionally formed the foundation of firm-level export equations and is a proxy for resources available to pay for sunk-entry costs into foreign markets,[5] economies of scope and demand externalities (Bonaccorsi, 1992; Sterlacchini, 2001). As shown by Davies *et al.* (2001), an accounting identity exists between export activity and total sales that distort any underlying causal relationship that may exist between the two variables. Consequently, we measure firm size by the value of domestic sales rather than total sales, since total sales include both domestic and foreign sales. To account for the possibility of a non-linear size-export relationship, we also include a squared term for size.

Product cycle and technology gap trade theories suggest that innovation is the driving force behind exports (Vernon, 1966; Krugman, 1979). R&D activity may increase the quality and design of exported goods, enabling them to compete more effectively in foreign markets. We measure innovative activity by research and development (R&D) intensity, captured by the ratio of R&D expenditure to domestic sales.

We include three variables that have been neglected in the empirical literature to date. First, we examine the potential role of product diversification. A more diversified firm is likely to have more products that will be profitable in foreign markets. Moreover, diversified firms will have proprietary assets that can be exploited in foreign markets (Jovanovic, 1993). We measure diversification as the percentage of total sales in all 3-digit secondary industries. A higher value for this variable indicates that the firm's output is relatively more diversified. Second, we capture firm director human capital by average director pay. Developing an exporting strategy is likely to require highly talented directors who have extensive foreign market knowledge and experience. The rationale of using average directors pay as an indicator of director talent rests on Mincer's (1974) human capital earnings function, which derives a relationship between earnings and education based on human capital. Third, we explore the impact of the level and variance of the Sterling-US Dollar exchange rate, as these partially determine expected profitability and uncertainty of entering export markets.[6] We construct a firm-specific exchange rate from the average daily exchange rate within the company accounts calendar period. Given that company account periods differ between firms, so the average annual exchange rate will vary accordingly. The impact of exchange rate variability on the decision to export is ambiguous *a priori*. On the one hand, a more variable exchange rate is expected to increase the uncertainty of profits from export sales in the foreign currency and, hence, risk-averse firms may not participate in export markets. Moreover, even though firms may be able to employ hedging strategies to overcome exchange rate variability, forward markets are unlikely to be complete for firms with long-term planning horizons. Alternatively, firms may judge entry into export markets as analogous to a financial or 'stock option' decision that is only exercised in favourable conditions. In this scenario, an increase in the variability of the exchange rate is equivalent to an increase in the value of the option (Franke, 1991; Sercu, 1992; Sercu and Vanhulle, 1992; De Grauwe, 2003). Consequently, exporting becomes more profitable when the exchange rate becomes more variable. However, results from theoretical models that have explored the potential impact of exchange rate risk on international trade are sensitive to the definition of exchange rate volatility, the presence or absence of mature forward exchange rate market and the timeframe of trade transactions (see, for example, Broll, 1994; Dellas and Zilberfarb, 1993).

Table 1: Variable definitions

Variable	*Description*
Export intensity	Value of exports/Value of total sales
SIZE	Value of domestic sales
DIV	Measure of firm diversification = 100-percentage share of primary 3-digit SIC sales
R&D	R&D intensity = R&D expenditure/total sales
WAGE	Average wage = Total remuneration/Total employment
DIRWAGE	Average director wage = Total director remuneration/Total number of directors
DOLLAR	Sterling-Dollar exchange rate calculated as the average daily rate over the account period
VDOLLAR	Variance of the daily Sterling-Dollar exchange rate over the account period

3. Data and results

All data is taken from *Datastream International* for 4933 UK publicly quoted firms.[7] Firms are classified by industry type according to the 1980 Standard Industrial Classification (SIC). All the variables incorporated in the model are available annually for the period 1988 to 2001. After excluding those firms with no export data, missing variables, and firms involved in the Agriculture sector (SIC Division 0), a total of 2137 firms remained of which 781 recorded no exports at some time.[8] Table 2 presents average export intensity for 1-digit SIC industries over the period. The figures show that the most export-intensive industries over the sample period are SIC-2 (extraction of non-fuel minerals and ores, manufacture of metals, mineral products and chemicals) and SIC-3 (metal goods, engineering and vehicles). In contrast, SIC-5 (construction) has the lowest export intensity. Industry differences in export activity will reflect differences in the tradability of products and the comparative advantage of firms within industries.

Table 3 presents descriptive statistics for the variables. The figures illustrate heterogeneity in sample means across 1-digit SIC sector divisions. We first test whether the Tobit model restriction applies for our data. Using the log-likelihood ratio test in eq. (2), we find that the Tobit model specification is rejected at the 1 per cent level of significance.[9] This implies that the estimated coefficients in eq. (1) are significantly different for the decision to export and the decision on export intensity, implying that the two decisions should be modelled separately. These results confirm previous findings by Wakelin (1998), Bleaney and Wakelin (2002) and Roper and Love (2002) for UK data. Therefore, we estimate a truncated model for export intensity on exporters only.

We initially estimated Probit and truncated equations without interactive industry dummy variables. Estimates are presented in Table 4. We include results from the Tobit specification for completeness. We then estimated Probit and truncated regression models with interactive industry dummies in order to explore the impact of explanatory variables within each industry. Under this specification, we obtain results shown in Table 5. In each specification we include 3-digit industry fixed-effects and year dummies.

3.1 Estimates without industry interactive effects

The first notable feature of the Probit equation is the size-exporting relationship is non-linear, having a 'U-shaped' relationship, indicating that export probability only increases with domestic sales once a critical size has been achieved. However, the estimated coefficient is such that the vast majority of firms are on the upward sloping part of the curve.[10] In the truncated regression, the size-exporting relationship is positive, indicating that the level of export intensity increases with firm size. Our results therefore indicate that being large is an advantage in entering and expanding into export markets, thereby confirming the important role of resources in determining export activity.

Table 2: Average export intensity by industry

Year / *SIC Division*	*1988*	*1989*	*1990*	*1991*	*1992*	*1993*	*1994*	*1995*	*1996*	*1997*	*1998*	*1999*	*2000*
1	30.95	32.00	38.07	25.05	32.63	30.63	28.56	28.66	27.35	28.38	22.75	22.59	20.83
2	40.20	44.05	43.83	44.70	50.40	53.46	52.55	54.11	56.13	52.97	53.37	52.53	53.94
3	35.14	36.19	38.44	39.57	40.26	43.12	46.44	47.83	47.69	48.54	49.79	49.07	51.78
4	22.58	23.57	26.02	26.70	28.57	30.01	30.41	31.11	31.60	31.55	33.13	33.18	34.39
5	10.59	10.40	13.88	14.93	17.56	19.27	22.08	24.83	27.30	23.34	23.58	19.78	21.47
6	24.22	26.87	27.78	27.96	27.78	27.94	29.07	31.00	30.19	28.39	28.93	30.11	27.35
7	38.66	40.24	37.41	35.85	37.68	33.56	31.97	40.37	46.28	43.66	39.44	38.41	38.51
8	26.92	30.00	34.15	31.25	30.66	34.95	32.43	34.37	36.81	33.79	33.71	36.45	36.03
9	24.50	28.09	28.28	27.28	32.23	33.59	35.57	37.26	36.89	37.83	34.67	38.99	40.97

Notes: Industry SIC (1980) divisions are: 1, energy and water supply; 2, chemicals/pharmaceuticals, non-metal products; 3, mechanical engineering and electronics; 4, food, drink and textiles; 5, construction; 6, distribution (retail and wholesale); 7, transport; 8, services, insurance and real estate; 9, miscellaneous products.

Table 3: Means and standard deviations of variables

		SIC division									
Variable	*Units*	*All industries*	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*
SIZE	£millions	530.45	545.99	694.31	280.72	351.86	348.19	650.54	1062.6	122.85	306.76
		(2314.3)	(1090.6)	(1837.1)	(903.3)	(1163.6)	(598.9)	(2849.2)	(2291.7)	(349.4)	(985.5)
DIV	Ratio	85.49	91.81	82.89	81.43	86.43	85.76	87.62	86.91	92.98	85.89
		(22.533)	(14.619)	(21.822)	(23.350)	(20.259)	(18.086)	(18.310)	(19.484)	(16.309)	(20.016)
R&D	£millions	0.0087	0.0019	0.0182	0.0181	0.0017	0.0003	0.0009	0.0023	0.0264	0.0042
		(0.0444)	(0.0045)	(0.0681)	(0.0462)	(0.0151)	(0.0014)	(0.0089)	(0.0121)	(0.0156)	(0.0366)
WAGE	£thousands	17.986	21.974	16.764	15.582	13.488	17.236	12.389	16.974	23.597	17.827
		(13.551)	(11.791)	(6.114)	(5.344)	(5.753)	(5.265)	(6.358)	(6.588)	(11.762)	(13.386)
DIRWAGE	£thousands	110.518	83.963	106.334	89.933	90.540	102.129	97.526	131.925	212.453	94.811
		(1376.13)	(78.86)	(91.92)	(82.40)	(76.44)	(62.74)	(82.30)	(139.85)	(4776.21)	(86.15)
DOLLAR	Dollars	1.6493	1.6463	1.6499	1.6563	1.6587	1.6549	1.6527	1.6383	1.6424	1.6394
		(0.0990)	(0.1020)	(0.0980)	(0.1006)	(0.1004)	(0.0983)	(0.0993)	(0.0962)	(0.0967)	(0.0962)
VDOLLAR	Dollars	0.5274	0.6249	0.5276	0.5647	0.5763	0.5287	0.5384	0.4032	0.4817	0.4784
		(0.6862)	(0.8820)	(0.6692)	(0.7101)	(0.7190)	(0.6532)	(0.6742)	(0.5555)	(0.6461)	(0.6362)
Sample		19650	573	1043	3197	2828	877	3059	385	1621	1131

Notes: All variables defined in Table 1. Industry SIC (1980) as shown in Table 2. Standard deviation in parentheses.

Table 4: Estimates of Tobit, Probit and Truncated (no industry interactive dummies, marginal effects)

	Tobit	*Probit*	*Truncated*
CONSTANT	-0.4442	0.0516	-1.3863***
	(1.639)	(0.290)	(4.466)
SIZE	-0.0838***	-0.0338**	-0.0098
	(3.632)	(2.229)	(0.374)
SIZE2	0.0077***	0.0032***	0.0040***
	(7.675)	(4.635)	(3.667)
DIV	0.0260***	0.0451***	0.0132***
	(7.667)	(19.090)	(3.444)
R&D	0.0036***	0.0013***	0.0019***
	(17.881)	(7.061)	(12.085)
WAGE	0.2528***	0.0987***	0.2444***
	(18.809)	(12.482)	(12.852)
DIRWAGE	0.0572***	0.0519***	-0.0015
	(4.877)	(7.017)	(0.107)
DOLLAR	-0.3132	-0.2408	-0.2416
	(1.177)	(1.365)	(0.802)
VDOLLAR	0.0105	0.0060	0.0049
	(1.209)	(1.028)	(0.515)
Number of observations	14594	14594	14594
Number of observations > 0	10635	10635	10635
Unrestricted log-likelihood	-16022.8	-5964.5	-7940.4
Restricted log-likelihood	-19244.7	-8530.5	-9276.4
McFadden R^2	0.1674	0.3008	0.1440
VZ R^2	0.4224	0.4827	0.2765
Count R^2	-	0.8058	-
Year dummy variables	13	13	13
Industry dummy variables	33	33	33
Scale factor	0.6925	0.2652	0.1844

Notes: *t*-statistics for original parameter estimates are contained in parenthesis. Original estimated coefficients can be obtained by multiplying the marginal effects by the reciprocal of Scale factor. A triple, double and single asterisk indicates that an estimated coefficient is significantly different from zero at the 1%, 5% and 10% level using a two-tailed *t*-test respectively. R-squared measures for the Probit model includes the number of correct predictions method (Count R^2) and Veall and Zimmermann's measure (VZ R^2). For comparison we compute the McFadden goodness-of-fit measure for all regressions (McFadden R^2). See Greene (2003) for details for these measures.

The second notable feature of the estimates is that the extent of product diversification has a positive impact on both export probability and export intensity. This suggests that mulit-product firms consider expansion into foreign markets and increased product diversification as complementary strategies, in the sense that more diversified firms are more likely to become exporters. This supports findings obtained by Davies *et al.* (2001) that for European firms, proprietary assets are exploited in both product and geographical space. Moreover, proprietary asset advantages, which are often correlated with diversification activity, enable firms to enter and expand into export markets more readily.

As regards the role of R&D intensity, this has a positive impact on both export probability and export intensity. This suggests that greater research effort (potentially reflected in improved product quality) is significant for both initial entry and expansion into export markets, providing support for product cycle and technology gap theories. However, caution is needed in interpreting this result. R&D intensity is an input measure of research effort and therefore may not be an accurate indication of innovative activity. As shown by Roper and Love (2002), the innovation-export relationship is sensitive to the measure of innovation. It may be the case that an output measure of innovative activity would have yielded a different result for the export probability equation.[11]

Human capital intensity, as measured by average wage, has a positive impact on both export probability and export intensity, indicating a more skilled workforce facilitates entry and expansion into foreign markets. Average director wage, reflecting director human capital, has a positive impact on export probability, suggesting that firms with talented directors, perhaps with knowledge of foreign markets, are more likely to become exporters. This lends support to survey evidence produced by Grant Thornton (2003) that having knowledge about the nature of foreign markets is crucial for successful entry into export markets. It may be the case that more talented directors have an informational advantage in developing an export strategy. However, average director wage has no statistically significant impact on the level of export intensity. It seems that once a firm has entered an export market, the information and knowledge advantages of directors is not important for increasing market penetration.

Surprisingly, exchange rates appear to have no significant impact on export probability or intensity. This may in part be due to the inclusion of year dummy variables and our estimation methodology, which we address later.

Summarising the results obtained so far, resources, employee and director human capital and innovation seem to play a major role in explaining UK firms' export activities. Furthermore, exchange rates do not appear to be important in explaining differences in export activity between firms.

3.2 Estimates with industry interactive effects

To explore the determinants of export activity in a more disaggregated manner, we interacted all explanatory variables with 1-digit SIC industry dummy variables. Estimates are given in Table 5. The default industry is SIC-3. For interacted variables we add a 1-digit SIC identifier. For example, the size variable for firms in SIC-4 becomes *SIZE4*. To obtain the overall impact of a variable in an industry, the coefficient on the default industry must be added. For example, in the Probit estimates contained in column 3, the coefficient of 0.1085 is added to -0.5134 in industry SIC-5 to obtain an overall negative impact for firm size in this industry.

We have included results from regressions with industry interactive effects using two separate methodologies. The first approach removes insignificant variables at the (two-tailed) 10 per cent level of significance (critical values are ±1.645) until all variables are significant. The results from these regressions are contained in columns three and five. The second approach estimates a 'best' regression equation for which the most variables are significant at the 10 per cent level of significance. Results from this approach are presented in columns two and four.

As far as firm size is concerned, the size-exporting relationship appears to be non-linear, having a 'U-shaped' relationship in a majority of industries for both the Probit and the truncated regressions. This result is in contrast to those obtained in Table 4, where firm size had a positive and linear impact on the level of export intensity. However, estimated coefficients are such that the vast majority of firms are on the upward sloping part of the curve, thereby supporting resource based explanations of firm export activity. We also find heterogeneity in the impact of firm size across industries, indicating the importance of examining more disaggregated data.

With respect to other explanatory variables, our results suggest that in a majority of industries higher levels of product diversification are strongly positively associated with both export probability and the level of export intensity, although there is relatively more industry heterogeneity in the export intensity equations. R&D intensity seems to exert a broadly positive impact on both export probability and intensity, thereby lending support to technology and innovation explanations of export performance. This result is consistent with those obtained in Table 4.

Firm human capital, proxied by average employee and director wages, has the expected positive effect on export probability and intensity in a majority of industries, confirming the results obtained in Table 4. However, there is evidence of industry heterogeneity. In SIC-1 (energy and water supply), for example, average employee wages have a negative impact on both export probability and the level of export intensity, suggesting that the dominant form of competition for firms in this industry is price competition.

The Sterling-Dollar exchange rate is negatively related to export probability in a majority of industries, indicating that appreciation of Sterling against the Dollar lowers entry into export markets. This is in contrast to the results obtained in Table 4 that indicate the level of the Sterling-Dollar exchange rate has no impact on export probability. This result supports the importance of exploring the disaggregated nature of the data. The impact of the variance of the Sterling-Dollar exchange rate is found to vary considerably across both industries and regression equations. In SIC-6 (distribution), for example, the variance of the Sterling-Dollar rate has a positive impact on export probability, but no impact on the level of export intensity. This is in contrast to SIC-2 (chemicals, non-metal products), for which the level of the Sterling-Dollar rate has no effect on export probability, but has a positive impact on the level of export intensity. These results arguably reflect industry-specific characteristics pertaining to the nature of the product traded and the form of international trade transactions that are practiced. Our results suggest that generalisations concerning the impact of exchange rate volatility at the aggregate level may not be supported at the industry-level.

In summary, our results from regressions with industry interactive effects are broadly in support of the resource-based, employee and director human capital and innovation explanations of firm-level export behaviour. However, there is evidence of industry heterogeneity, particularly with respect to the impact of exchange rate volatility.

Table 5: Estimates of probit and truncated models (with interactive industry dummies, marginal effects)

Model	*Probit(maximum no. oft's >1.645)*	*Probit(All t's > 1.645)*	*Truncated(maximum no. oft's >1.645)*	*Truncated(All t's > 1.645)*
Constant	-0.4446***	-0.5361***	-2.1836***	-1.8004***
	(2.796)	(3.761)	(8.345)	(14.412)
SIZE	0.1435***	0.1085***	0.1925***	0.1154***
	(4.623)	(3.767)	(4.659)	(14.810)
SIZE1	0.0634	0.0858*	-0.4726***	-0.4163***
	(1.182)	(1.660)	(4.167)	(4.044)
SIZE2	-0.6560***	-0.5819**	-	-
	(2.618)	(2.474)	-	-
SIZE4	-0.1094***	-0.0663***	-0.2246**	-0.0903***
	(5.093)	(6.664)	(2.287)	(4.701)
SIZE5	-0.5520***	-0.5134***	-0.2793***	-0.0787**
	(7.655)	(7.271)	(2.996)	(2.214)
SIZE6	-0.2498***	-0.2146***	-0.3202***	-0.2371***
	(6.578)	(5.923)	(4.276)	(3.755)
SIZE7	-0.2876**	-0.1145***	-	-
	(2.476)	(4.712)	-	-

Estimates of probit and truncated models *cont...*

SIZE8	-0.2757***	-0.2431***	-0.4042***	-0.3299***
	(6.167)	(5.614)	(5.194)	(4.943)
SIZE9	-0.2720***	-0.2394***	-0.3062***	-0.2466***
	(6.379)	(5.860)	(3.847)	(3.640)
$SIZE^2$	-0.0041***	-0.0028*	-0.0031*	-
	(2.724)	(1.866)	(1.821)	-
$SIZE^2 1$	-0.0057**	-0.0065***	0.0153***	0.0123**
	(2.344)	(2.711)	(2.881)	(2.512)
$SIZE^2 2$	0.0375***	0.0345***	-0.0018***	-0.0018***
	(2.831)	(2.767)	(4.084)	(4.746)
$SIZE^2 4$	0.0035***	0.0018**	0.0078*	0.0024***
	(3.254)	(2.325)	(1.949)	(2.853)
$SIZE^2 5$	0.0267***	0.0252***	0.0083*	-
	(7.992)	(7.641)	(1.870)	-
$SIZE^2 6$	0.0092***	0.0078***	0.0110***	0.0076***
	(5.147)	(4.455)	(3.624)	(3.047)
$SIZE^2 7$	0.0136***	0.0065***	0.0043***	0.0041***
	(2.652)	(4.643)	(4.213)	(4.416)
$SIZE^2 8$	0.0128***	0.0115***	0.0169***	0.0138***
	(5.722)	(5.213)	(4.833)	(4.534)
$SIZE^2 9$	0.0103***	0.0090***	0.0118***	0.0088***
	(4.931)	(4.360)	(3.317)	(2.943)
DIV	0.0159***	0.0166***	-0.0450***	-0.0367***
	(6.033)	(6.551)	(8.030)	(7.920)
DIV1	0.0123	-	-	-
	(1.287)	-	-	-
DIV2	-0.0400***	-0.0395***	0.0228**	-
	(3.573)	(3.547)	(2.050)	-
DIV4	-	-	0.0580***	0.0501***
	-	-	(5.403)	(4.886)
DIV5	0.0139**	0.0134**	0.0615*	-
	(2.071)	(2.005)	(1.693)	-
DIV6	0.0345***	0.0340***	0.0637***	0.0541***
	(8.542)	(8.546)	(5.281)	(4.650)
DIV7	0.0279***	0.0270***	0.0869***	0.0664***
	(2.665)	(2.709)	(3.280)	(2.679)
DIV9	0.0152**	0.0145**	0.0302*	-
	(2.494)	(2.405)	(1.652)	-

Estimates of probit and truncated models *cont...*

R&D	0.0008***	0.0008***	0.0029***	0.0028***
	(6.349)	(6.644)	(12.251)	(12.166)
R&D1	0.0070**	0.0061**	-	-
	(2.358)	(2.110)	-	-
R&D2	-	-	-0.0016***	-0.0015***
	-	-	(3.717)	(3.630)
R&D4	0.0771***	0.0771***	0.0036*	0.0039**
	(4.376)	(4.386)	(1.958)	(2.150)
R&D5	1.0765*	1.1092**	0.0413***	0.0525***
	(1.928)	(1.986)	(2.600)	(3.446)
R&D7	0.0086*	-	-	-
	(1.697)	-	-	-
R&D8	-	-	-0.0013***	-0.0012***
	-	-	(3.678)	(3.564)
R&D9	0.0058**	0.0067**	-0.0029***	-0.0029***
	(2.011)	(2.300)	(3.941)	(4.046)
WAGE	-	-	0.1355***	0.1379***
	-	-	(5.728)	(5.857)
WAGE1	-0.0724***	-0.0857***	-0.2522***	-0.2517***
	(2.734)	(3.415)	(4.760)	(4.851)
WAGE2	0.0891**	0.0971**	0.3186***	0.3064***
	(2.103)	(2.473)	(4.810)	(4.668)
WAGE4	0.0803***	0.0813***	-	-
	(6.579)	(6.677)	-	-
WAGE5	-	-	0.7604***	0.4357***
	-	-	(3.993)	(3.527)
WAGE6	0.1267***	0.1243***	0.2159***	0.2084***
	(11.781)	(11.697)	(5.279)	(5.224)
WAGE7	0.0859*	0.0754*	0.3818***	0.3869***
	(1.809)	(1.796)	(3.423)	(3.653)
WAGE8	0.0573***	0.0604***	0.1967***	0.1867***
	(3.477)	(3.735)	(3.802)	(3.696)
WAGE9	0.0328**	0.0338***	0.1793***	0.1393***
	(2.560)	(2.653)	(3.106)	(2.588)
DIRWAGE	-0.0269	-	0.0385**	0.0449***
	(1.529)	-	(2.521)	(2.991)
DIRWAGE1	0.1806***	0.1629***	-	-
	(5.742)	(6.519)	-	-
DIRWAGE2	0.0618*	-	-	-
	(1.803)	-	-	-

Estimates of probit and truncated models *cont...*

DIRWAGE4	0.0759***	0.0493***	0.1129***	0.0959***
	(3.623)	(4.249)	(3.235)	(2.777)
DIRWAGE5	-0.0537**	-0.0832***	-0.2119**	-0.2669***
	(1.962)	(3.956)	(2.084)	(2.770)
DIRWAGE6	0.0697***	0.0409***	-0.2163***	-0.2251***
	(3.477)	(4.169)	(6.206)	(6.481)
DIRWAGE7	0.0406	-	-0.5507***	-0.5702***
	(1.243)	-	(8.897)	(9.539)
DIRWAGE8	0.0757***	0.0498***	-	-
	(3.294)	(3.313)	-	-
DIRWAGE9	0.0918***	0.0672***	-0.0636	-
	(4.234)	(5.360)	(1.198)	-
DOLLAR	-0.3584**	-	-0.4001***	-0.3895***
	(2.385)	-	(3.579)	(3.537)
DOLLAR1	0.2640	-	1.0772	-
	(1.106)	-	(1.609)	-
DOLLAR2	0.4830*	-	-	-
	(1.647)	-	-	-
DOLLAR4	0.2942*	-	-	-
	(1.946)	-	-	-
DOLLAR5	0.4410*	0.3046*	-	-
	(1.794)	(1.768)	-	-
DOLLAR6	0.2235	-	-	-
	(1.395)	-	-	-
DOLLAR8	0.2316	-	-	-
	(1.352)	-	-	-
DOLLAR9	0.2934	-	-	-
	(1.556)	-	-	-
VDOLLAR2	-	-	0.0414***	0.0417***
	-	-	(2.944)	(2.987)
VDOLLAR5	0.0121	-	-0.0770	-0.1467***
	(1.102)	-	(1.600)	(3.007)
VDOLLAR6	0.0092*	-	-	-
	(1.655)	-	-	-
VDOLLAR7	0.0207	-	-0.0397	-
	(1.386)	-	(-1.257)	-
VDOLLAR8	-	-	0.0510***	0.0507***
	-	-	(3.099)	(3.075)

Estimates of probit and truncated models *cont...*

No. of observations	14594	14594	14594	14594
No. of observations >0	10635	10635	10635	10635
Unrestricted log-likelihood	-5562.2	-5582.8	-7659.9	-7686.0
Restricted log-likelihood	-8530.5	-8530.5	-9276.4	-9276.4
McFadden R^2	0.3480	0.3456	0.1743	0.1745
VZ R^2	0.5365	0.5339	0.3241	0.3197
Count R^2	0.8220	0.8209	-	-
Year dummy variables	13	12	0	0
Industry dummy variables	30	26	29	24
Scale factor	0.2154	0.2083	0.2039	0.1994

Notes: *t*-statistics for original parameter estimates are contained in parenthesis. Original estimated coefficients can be obtained by multiplying the marginal effects by the reciprocal of the scaling factor *Scale factor*. A triple, double and single asterisk indicates that an estimated coefficient is significantly different from zero at the 1%, 5% and 10% level using a two-tailed *t*-test respectively. All major variables are interacted with 1-digit industry dummy variables. *R*-squared measures for the Probit model includes the number of correct predictions method (Count R^2) and Veall and Zimmermann's (VZ R^2) measure. For comparison we compute the McFadden goodness-of-fit measure for all regressions (McFadden R^2). See Greene (2003) for further details.

4. Conclusions

In this paper we explored the determinates of export probability and intensity for an unbalanced panel of UK firms over the period 1988 to 2001 and find support for most of the theoretical explanations of firm-level export activity. In general, more research intensive and diversified firms with a larger resource base and skilled workforce are more likely to export, though some industries may compete on labour costs rather than product quality and design. Director (human) capital is important for UK firms to enter export markets, but not to expand into export markets. This result suggests the important role of market information and knowledge constraints for the decision to export. Our results also indicate heterogeneity between industries with respect to the impact of firm-level variables.

The inclusion of firm-specific exchange rates provided some intriguing insights into export behaviour and confirms the importance of modelling firm-specific reactions to price shocks. Our results indicate that the level of Sterling has a significant impact on both market entry and expansion decisions, but that the impact of Sterling volatility varies considerably between industries.

From a policy perspective, our results emphasise the importance of distinguishing between policies designed to increase export penetration of UK firms and those formulated to extend existing foreign market penetration. Furthermore, policy makers need to design export promotion policies that are industry-specific.

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ENDNOTES

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2. For coverage of recent UK competitiveness policies see Department of Trade and Industry (2003).

3. For a review of the recent literature see Zou and Stan (1998).

4. Log versions of the variables are used in estimation.

5. Sunk costs may include, for example, marketing, distribution and adapting products for foreign markets.

6. The Sterling-Dollar rate was chosen as the representative exchange rate because of the global importance of the US Dollar as an internationally traded currency. Although a composite (trade) weighted index may more accurately capture the influence of exchange rates for UK firms, the frequency of trade data prevents the construction of an average daily exchange rate index unique to each firm in our sample.

7. The panel is not balanced and therefore includes firms that move in and out of the sample.

8. Following comments made by the anonymous referee concerning the values of R&D intensity, further removal of data took place. For this analysis, observations were removed when R&D exceeded 30 per cent of the value of sales, leaving 14594 observations.

9. The test statistic is 4235.8.

10. The turning point for the probit regression in Table 4 is a firm size of £196.61million.

11. However, Griliches, Pakes and Hall (1987) and Hall (1990) have found that patents (an output measure of innovative activity) and R&D are typically highly correlated at the firm level, with patents being a far noisier measure than R&D.

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