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Causality between Exports, Productivity and Financial Support in EU Agriculture

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Abstract:
The aim of this paper is to investigate the causal relationship between exports and productivity and exports and agricultural support within the European Union. Using the ARDL approach to cointegration and error correction models, we find evidence of exports within the EU being determined by support in Ireland and France, as well as gains in productivity contributing to export growth in Germany and the UK. This finding may help explain why some countries within the EU, such as France have large agricultural trade surpluses, whilst others run large deficits.

JEL: R11, Q14, Q17, N54

Keywords: CAP, Exports, Financial Support, Productivity.

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1 Introduction

The aim of this paper is to determine the direction of causality between agricultural exports within the European Union and productivity[1], using the recently developed Autoregressive Distributed Lag (ARDL) approach to cointegration and error correction models. Unlike previous studies we also assess the directional effects between agricultural exports and agricultural support, given the importance of agricultural support payments within the EU over the last thirty years. This allows us to decide whether trade within the EU agricultural sector is determined primarily by productivity or levels of support.

There have recently been a number of changes to the common agricultural policy (CAP), mainly as a result of the addition of the new member states from Eastern Europe. The main objectives of Agenda 2000 have been to make the working of the CAP simpler and ensure financial discipline is maintained. However there are important welfare implications associated with the addition of the new member states and attempts to restructure agricultural support, which will inevitably affect some member states more than others. It is therefore important to investigate what has determined member states trade in agricultural produce over the recent past, in order to appreciate how these changes will affect the member states in the future.

To date there have been relatively few empirically based studies into the effects of the common agricultural policy (CAP) on agricultural trade within the EU, despite agricultural expenditure being the largest single sector of the EU budget and substantial differences between the member's exports. The main study into the relationship between productivity and exports was by Arnade and Vasavada, 1995,

who found very little evidence of any causality between productivity and exports in Asia and the Americas. The study presented here builds on Arnade and Vasavada's work by using an approach better suited to the limited amount of data available for the EU, as well as including an error correction term to determine long-run causality

The paper is structured as follows. Section 2 provides an outline of the literature theory linking productivity and exports and highlights the paucity of work in the area of agriculture in developed economies. It is this gap that the paper seeks to fill using an autoregressive distributed lag (ARDL) approach which is developed in Section 3. The results are given in Section 4 while Section 5 concludes.

2. Productivity, Exports and the CAP

Exports and Productivity: a review

Theory posits some clear links between exports and growth or total factor productivity (see for example Bhagwati, 1978, and Grossman and Helpman,1991) especially via the export-led growth hypothesis. While not explicitly stating direction of causality, implicitly the hypothesis assumes that exports drive improved economic performance in the economy as a whole. As Kunst and Marin, 1989, highlight exports generate improved productivity as they: concentrate resources in the most efficient sectors; allow economies of scale to be achieved; improve performance due to the influence of competitive world conditions and finally by generating spill-over effects into other sectors of the economy. As such, it is the nature of the competitive process that forces industries to be more productive and more efficient in their use of resources.

There has been a wealth of papers exploring this relationship with a focus on the export-led growth hypothesis including for developing countries inter alia Michaely, 1977, Balassa, 1978, Feder, 1982, Greenaway and Sapsford, 1991, while for developed economies papers include inter alia Marin, 1992, and Yamada, 1998. Results suggest that exports and growth do appear to correlate but there is little consideration given explicitly of two-way causality, as the hypothesis is established as running one way only.

The counter argument suggests productivity growth drives export growth in that improvements in productive efficiency can lead to lower costs which in turn make domestically produced goods more attractive on the world market. The issue of causality is clearly important for policy makers so as to ensure policy prescriptions are correct – should they focus on making access to export markets easier or should they focus on improving factor productivity such as through training and education of labour for example?

The debate over the causal relationship between exports and productivity is an important but empirically testable one with different approaches used. Kunst and Marin, 1989, using Granger causality testing, examine the relationship for Austrian manufacturing and find that there is no causal link from exports to productivity while there is a positive link from productivity to exports, the improved productivity arising from factors other than trade effects. Marin, 1992, employs a VAR approach to data for a sample of developed economies and finds exports Granger-cause labour productivity in a number of cases. The VECM approach is taken by Hacker and Hatemi-J, 2003, in their analysis of total Swedish exports and total factor

productivity. Their results suggest two-way causality, whereas Greenaway and Kneller, 2004, find that the impact of exports on productivity for UK manufacturing firms is positive but only small and short lived. Contrarily, Awokuse, 2003, shows strong uni-directional causality from exports to growth in Canada, a result that Baldwin and Gu, 2004, confirm for Canadian manufacturing, where exports lead to greater plant productivity through exposure to competition, achieving economies of scale and learning by exporting.

We are aware of few papers that analyse exports and productivity in agriculture, with only Arnade and Vasavada, 1995, offering an empirical evaluation of causality. Their econometric study of Asian and Latin American countries showed no causation from productivity growth to export growth and the reason given was that increased income arising from productivity growth is spent on agricultural products domestically and that shifts in demand offset supply shifts arising from productivity gains. Similarly, Hoekman et al, 2004, explore agricultural sector responses, including financial support, to trade policy reform in developing countries and show how reform of border measures by OECD countries can significantly influence the level of exports and hence potentially growth of developing countries[2], whereas Hertel, 1989, establishes a theoretical argument for a positive causal link from agricultural support to exports. A gap exists therefore in evaluating the causal relationship in the case where the agricultural sector is relatively small, where generating exports is not a policy aim and where the sector is not viewed as an engine for growth, features that characterise most developed market economies including the EU and the CAP.

The Impact of the CAP on Exports and Productivity

When the CAP was devised in the early years of the EU, among the major goals were those of increasing food supplies by raising productivity and ensuring that smaller farmers' incomes were raised to a "reasonable" level, Grant, 1997. Improving productivity was intended to drive up incomes, Ackrill, 2000, and was not aimed at generating exports but more at ensuring adequate supplies for consumers. The expansion of domestic supply depends on the cost structure and land structure of farming, along with the ability of farmers to take advantage of any possible scale economies that might exist. The CAP policy framework of institutionally determined prices set behind a trade barrier could be argued to be a feasible solution to raising productivity, hence support drives productivity. However, the difficulty for policy makers is that the incentive structure for farmers was changed and a high and guaranteed domestic price plus import protection presents a relatively low-risk environment in which farmers operate. Investment would rise and output would increase at all price levels, causing the supply curve to shift right. As Figure 1 shows, this not only causes the levels of imports to shrink over time (given a relatively static demand schedule) but also ultimately means that the former net-importing economy becomes a net exporter. Thus it appears that productivity drives exports in this case.

[Figure 1 here]

Here therefore, the policy has induced an increase in productivity, which in turn has lead to a switch from the country being an importer to an exporter of the product. The EU has shown evidence of such an evolution, especially in the grains and beef markets and thus it could be argued that the policy has been highly effective in increasing output. However, this has come at a significant price as surpluses have to be stored or exported with subsidy. These policies are very expensive to run, have

created trade disputes with both developed and developing countries and have also hampered the process of assimilating the central and eastern European countries (CEECs). The MacSharry reforms of 1992 and Agenda 2000 have sought to reduce the degree of intervention in markets by cutting support prices, limiting access to beef intervention, reducing export subsidies and also the volume of subsidised exports.

While recent proposed reforms to the sugar regime suggest complete elimination of subsidised exports, there is generally a lack of detail in terms of time frame for completing general export subsidy removal. The aim is to reform policy such that surpluses that arise from trade distorting policies are reduced and that greater emphasis is placed on producing more of what the consumer wants and responding less to institutionally set prices and incentives.

In summary, therefore, causality between exports and productivity is not agreed on theoretically or empirically. The EU's CAP provides a good case of testing given the impact support policies have had on raising productivity and hence on export levels.

3. Methodology

To determine the causal relationship between exports and productivity and exports and agricultural support, we will conduct the standard Granger non-causality tests, Granger *et* al., 2000, between exports and productivity and exports and financial support using the following generalised ECM:

$$\Delta y_t = \alpha_0 + \alpha_1 ect_{t-1} + \alpha_2 \sum \Delta y_{t-i} + \alpha_3 \sum \Delta x_{t-i} + u_t \qquad (1)$$

Where *ect* are firstly the residuals from a cointegrating relationship between real intra EU agricultural exports as a proportion of total real intra-EU agricultural exports (*e*) and real agricultural support payments (*s*) and vice versa. In the second set of causality tests, *ect* are the residuals from a cointegrating relationship between real intra EU agricultural exports as a proportion of total real intra-EU agricultural exports (e) and productivity as represented by the ratio between output and inputs consumed (*pr*) and also vice versa[3]. (All variables are in logarithms). Long-run causality is then measured through the significance of the error correction term and short-run causality by the joint significance of the lagged differenced explanatory variables.

In the long-run we express the export variable as the ratio between real intra-EU exports for each country and total real intra-EU exports for the EU to overcome the problem of new members being admitted to the EU during the estimation period. In doing so, we are creating a variable that has the same effect as real intra-EU exports, with the effect of new EU members netted out, and is thus consistent with the theory discussed earlier. In addition, we have used a similar approach to our productivity variable by taking the ratio between outputs and inputs, a representation that has been used in similar studies which link the theory to the empirical tests as, for example, in Arnade and Vasavada, 1995.

We have used the autoregressive distributed lag (ARDL) approach to cointegration (see Pesaran *et al.*, 2001) rather than some of the other approaches, as it has good small sample properties in comparison to these techniques, as well as circumventing the problem of the order of integration of the individual variables. The resulting error correction models (ECM) are then used for the Granger non-causality tests, as

suggested recently by Faria and Leon-Ledesma, 2003. An advantage of using a bi-variate approach to testing for causality is that it allows us to test for both short-run causality through the lagged differenced explanatory variables and long-run causality through the error correction term.

The ARDL approach to cointegration (see Pesaran *et al.*, 2001) involves estimating the following conditional error correction version of the ARDL model[4]:

$$\Delta y_t = \alpha_0 + \alpha_1 y_{t-1} + \alpha_2 x_{t-1} + \sum_{i=1}^{p-1} \delta \Delta y_{t-i} + \sum_{i=1}^{p-1} \phi \Delta x_{t-i} + \gamma \Delta x_t + u_t \quad (2)$$

We then 'bounds test' for the presence of a long-run relationship between the two models using two separate statistics. The first involves an F-test on the joint null hypothesis that the coefficients on the level variables are jointly equal to zero (See Pesaran *et al.*, 2001). The second is a t-test on the lagged level dependent variable. The statistics have a non-standard distribution and depend on whether the variables are individually *I*(0) or *I*(1).

Instead of the conventional critical values, this test involves two asymptotic critical value bounds, depending on whether the variables are *I*(0) or *I*(1) or a mixture of both. If the test statistic exceeds their respective upper critical values, then there is evidence of a long-run relationship, if below we cannot reject the null hypothesis of no cointegration and if it lies between the bounds, inference is inconclusive. If the test statistic exceeds its upper bound, then we can reject the null of no cointegration regardless of the order of integration of the variables.

The conditional long-run model can then be produced from the reduced form solution of (2), when the first-differenced variables jointly equal zero. The long-run coefficients and error correction model are estimated by the ARDL approach to cointegration, where the conditional ECM is estimated using OLS and the lag structure for the ARDL specification of the short-run dynamics is determined by the Schwarz-Bayesian criteria, whilst testing to ensure there is no problem with autocorrelation. We have started from the basis that there are at least two lags present in the ARDL model, in order to ensure a lagged explanatory variable in the ECM, which are used to determine short-run causality, as in Arnade and Vasavada, 1995.

4. Results

The investigation was carried out on seven individual members of the CAP (France, Germany, Italy, UK, Netherlands, Denmark and Ireland) and one combination (Belgium and Luxembourg). We were restricted to this latter combination as a result of the majority of the export data being presented in a combined form. The other seven countries were members of the European Community before 1975, which is when the data begin and also when the EAGGF guarantee scheme in its present form was set up. The data are all annual and run from 1975 to 2002 and all are taken from the European Commission's *Eurostat*.

The export measure we use are real intra-EU export values as a proportion of total real intra-EU export values[5]. The agricultural support data are the EAGGF guaranteed support[6], the productivity data are the ratios between agricultural output and consumption of inputs for each country, although there are other measures of

productivity, such as Total Factor Productivity (TFP), data limitations meant we have used this basic measure of productivity as suggested in other similar studies such as Arnade and Vasavada, 1995. The price data are the main agricultural indices as provided by the European Commission's Eurostat. The Gross Domestic Product (GDP) variables are all taken from the *International Financial Statistics* (IMF) and are in real form. The GDP variable used in all the multivariate tests consisted of the EU GDP minus the GDP of the country being tested.

[Figures 2 and 3 here]

As is evident from Figures 2 and 3, France and Germany are the main beneficiaries of subsidies in the EU, whilst productivity within the EU agricultural sector has increased over recent years, with the Netherlands having the largest increase and perhaps more surprisingly, Irish farming appears to be less productive than when it joined. The general recent slowing down in productivity might reflect the success of policy reform in limiting attempts to raise productivity after concerns about surplus production became greater. The high level of productivity in Italian agriculture could simply be due to the different structure of Italian agriculture relative to the rest of the sample. For instance, the average size of a farm in Italy is approximately 10% of that in the UK. As much of the farming in Italy is subsistence based, much of the cost of labour inputs is not included in the data. In figure 4 we have real intra-EU exports as a proportion of total intra-EU exports, the Netherlands are the largest intra-EU exporters enjoying approximately 20% of the market, in contrast the UK has about 5%, reflecting the general balance of supply and demand in her domestic market.

[Figure 4 here]

ADF tests for stationarity were conducted and indicated most variables are I(1). But as some are I(0) the conventional cointegration tests are inappropriate[7], this requires

the use of the ARDL bounds testing approach, such that if the statistic exceeds its upper bounds, then there is evidence of cointegration regardless of whether the individual variables are I(0) or I(1). To test for a long-run relationship we have used the ARDL approach, where the optimal number of lags is determined by the Schwarz-Bayesian criteria, whilst ensuring there is no evidence of autocorrelation. To allow us to test for short-run causality through the lagged explanatory variables, we have included a minimum of two lags in each ARDL regression. According to Gonzalo, 1994, the costs of over-parameterisation in terms of efficiency loss is marginal, but this is not the case in the event of under-parameterisation. Also as Pesaran *et al.,* 2001 have shown, this test is very sensitive to the presence of autocorrelation, where autocorrelation was present further lags have been added until the problem is solved.

[Tables 1 and 2 here]

The results of the *F* and *t* statistics are reported in Tables 1 and 2. There is some evidence of a long-run relationship where exports are the dependent variable for France, Germany, Ireland and Italy but less evidence of a long-run relationship when agricultural support is the dependent variable, except for Germany and Belgium. Similarly with the productivity results, there is some evidence of the existence of a long-run relationship when exports are the dependent variable for Germany, France, Italy and the UK, and some evidence of a long-run relationship when productivity is the dependent variable for France and particularly Ireland. We have then moved on to the Granger non-causality tests. As Toda and Phillips, 1993 have shown, if there are no cointegrating vectors present, the diagnostic statistics used in causality tests can still have the appropriate distributions. So when testing for the presence of causality, we have included results with the error correction term and without, as in other studies such as Granger *et al.,* 2000 using this approach.

[Table 3 here]

Tables 3 and 4 contain the Granger non-causality tests for all the countries tested. Evidence of cointegration between the two variables is a necessary but not sufficient condition for rejecting Granger non-causality from the explanatory variable to the respective dependent variable. We therefore test for both long and short run causality using the appropriate ECM. The joint significance of the lagged differenced explanatory variables is tested using the Wald statistic and the error correction term is tested with just the t-statistic. The diagnostic tests also included in these tables suggests the ECMs are well specified overall, therefore suggesting no omitted variable bias. Of those countries where cointegration was present, there is evidence that agricultural support has encouraged exports in the long run for France and Ireland, but no evidence of any short-run causality.

These results tend to indicate a redistributive effect of the CAP with some countries increasing their exports and thus output through the beneficial use of the agricultural support and lends credence to the results from Domenech *et* al., 2000, which also indicated a redistributive effect of the EAGGF subsidy system in the EU. When support payments are the dependent variable both Belgium/Luxembourg and Germany shows signs of long-run causality. The results on productivity and exports show that of those countries where cointegration was present, only Germany and the UK provide any evidence of long-run causality from productivity to exports. Both France and Ireland show evidence of long-run causality from exports to productivity. Overall these results mirror those of Arnade and Vasavada, 1995 in that there is very little evidence of short-run causality between exports, agricultural support and productivity. However due to the inclusion of the error correction term, there is some

evidence of long-run causality. Both France and Ireland seem to have benefited from the high levels of agricultural support that they receive, and this has encouraged their exports to other member states. In addition for both countries exports have had a long-run effect on productivity, possibly implying some evidence of export-led productivity growth. Alternatively this could be picking up the fact that over the last thirty years both France and Ireland have had some sub-sectors of their agricultural sectors that were relatively successful.

[Table 4 here]

In contrast for both Germany and the UK it appears that their exports have been largely due to increased productivity in their agricultural sectors rather than any beneficial effects of the support system. Both countries were traditionally large importers but have moved to being net exporters in some areas and in the case of Germany, account must be taken of the unification of east and west, which mixed the larger relatively efficient farms in the east with the small, inefficient farms in the west

With countries like Denmark and the Netherlands, there seems to be little evidence of any relationship between exports, support and productivity, possibly because both countries have tended to specialise in products which receive relatively little support, particularly pig products. These results showing a varied relationship between exports, agricultural support payments and productivity across the EU members, supports recent studies which indicate that the Agenda 2000 reforms will have mixed effects across member states (Philippidis and Hubbard, 2003). This suggests the effects of the CAP have not been uniform across member states and are unlikely to be so in the future.

[Table 5 here]

We also found that for all the countries, when the error correction term is removed from the causality tests, there is no evidence of short-run causality between any of the variables, as was also the case in Arnade and Vasavada, 1995. The results in Table 5. are from a set of tests incorporating all three variables into the Granger non-causality tests, as well as an EU GDP variable. We conducted a further set of tests incorporating all three variables into the Granger non-causality tests, as well as an EU GDP variable. This was done through the inclusion of these extra variables as lagged differenced variables in the ECM, rather than through the error correction term. This was due to the small sample problems we would have encountered if we had used a standard Maximum Likelihood based multivariate cointegration technique and because we wished to retain the long-run bi-variate causality results which we obtained by using a bi-variate error correction term. When the tests were done with the productivity and EU GDP variables included in the tests between exports and financial support, there is very little evidence that the lagged differenced variables had any short-run effect on the result from the corresponding causality tests. This was also the case when the financial support variable was added to the causality tests between productivity and exports. This indicates that there is very little evidence of omitted variable bias in our results or of EU GDP as a whole causing exports, productivity and support, this provides further evidence to the usual result that demand for agricultural products is income inelastic.

5. Conclusion

The evidence from this study suggests that EU agricultural exports are not determined primarily by levels of productivity, as with studies in both Asia and America.

However there is some evidence to suggest in the EU, levels of support have had an effect on agricultural exports. This is particularly evident in countries like Ireland, whom since joining the CAP in the early 1970s have enjoyed disproportionately large amounts of EU support. Only in the UK and Germany, whom have traditionally had some of the most productive farms in the EU, is there any evidence of productivity affecting exports. It appears that both France and Ireland have enjoyed some export-led growth in agricultural productivity during the recent past, which was one of the original aims of the CAP.

With the introduction of the new member states and need to control expenditure on agriculture within the EU, the results from this study not only suggest important welfare implications for farming across the EU, but also substantial affects on trade within the EU with regard to agricultural produce. In particular countries like Ireland, whom have traditionally received high levels of support, will possibly not only see those support payments fall in coming years as reforms continue, but could also find there is a relative decline in their important export trade in the EU. In addition the relative lack of evidence that changes in productivity affect export trade, imply that new member states may not enjoy substantial increases in agricultural trade within the EU, even if their productivity levels are increased substantially over the coming years.

Further research is required into the effects of the CAP on trade in agricultural goods within the EU, particularly as attempts are made to reduce the levels of agricultural support in the EU and other industrialised economies. Clearly as with Arnade and Vasavada, 1995, a longer data span would improve the tests as would additional data on productivity which specifically measured labour and capital productivity

End Notes

[1] The terms productivity and exports usually refer to aggregate quantities, whereas in this study the terms refer specifically to productivity and intra-EU exports in the agricultural sector, as in Arnade and Vasavada, 1995.

[2] The relationship between exports and financial support in a developed country context is not explicitly discussed in the literature. However for a review of the relationship between financial support and economic output in the EU and thus indirectly exports, see Domenech *et. al*. (2000).

[3] We also conducted the causality tests including a dummy variable for the Macsharry reforms, the variable consisting of zeros before 1992 and ones thereafter. However this did not significantly affect the results and in most cases the dummy variable was insignificantly different to zero at the 5% level of significance. In a similar way we conducted Chow tests for structural stability, using the Macsharry reforms of 1992 as the structural break, the results supported the findings of the dummy variable tests.

[4] The Pesaran *et al.*(2001) approach to cointegration involves the inclusion of a contemporaneous effect, which they argue would be uncorrelated with the disturbance term u_t by construction. They also argue that given the unrestricted nature of the lag distribution of the conditional ECM, it would be difficult to find suitable instruments for any instrumental type approach to estimating this equation. This approach to Granger non-causality tests has been used in other studies such as Faria and Leon-Ledesma (2003).When conducting the Granger non-causality tests, we have only used the lags to test for short-run causality.

[5] Tests were also carried out using total exports as well as extra-EU exports, but in general the results were not as good so are not reported

[6] We have used the EAGGF guarantee data to represent overall support, as we feel it better represents the long-run subsidy to the member states.

[7] The results are not reported as they are not important for this test but are available from the authors on request. The standard cointegration tests are inappropriate for other reasons, for instance the Johansen ML test requires a large data sample, whereas the ARDL bounds test has good small sample properties.

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Appendix 1 Data Presentation

The data used in this study is taken from the European Commission's *Eurostat* yearbook publications (various issues) except the EU GDP data which was taken from the *International Financial Statistics* (IMF).

Exports: The export measure we use are real intra-EU export values as a proportion of total real intra-EU export values. The reason we use the export ratio, is due to the new member states joining the EU during the sample period, which automatically leads to an increase in intra-EU exports. By expressing the intra-EU exports as a proportion, we remove this effect. Real intra-EU exports have been deflated using the country's domestic agricultural prices index, while total intra-EU exports were deflated using an average EU agricultural price index. To take account of the fact that a series for intra-EU exports during the sample period would contain breaks when new countries joined the Union, we constructed our own EU price index made up of the three largest exporters; France, Germany and the Netherlands. Where goods are imported into a member state from outside the EU, then subjected to a legal operation, before being exported to another member state, these are recorded as an export from the initial member state.

Productivity: The productivity measure is based on a country specific Cobb-Douglas production function, where the inputs are made up of the usual mix of capital and labour inputs. This follows the approach in Arnade and Vasavada (1995), although in this approach the inputs are more comprehensive than the individual inputs of labour, land, tractors and fertilizer that were used in that study. For instance the input data here includes seeds, veterinary expenses etc (More information on this is available in

'Statistical and Economic Information' Eurostat (various issues)). The output measure is made up of agricultural output sold by agricultural units, held in stock on the farms, or used for further processing by the agricultural producers and the same principal applies to the consumption of inputs. Both agricultural outputs and inputs are taken from the Table titled 'Basic Data – Key Agricultural Statistics'.

Financial Support: The data relating to financial support is the European Agricultural Guidance and Guarantee Fund (EAGGF) data.

EU GDP: This is real GDP in the EU members, measured in Euros, which is updated to account for new members joining during the time span investigated in this study. We have then removed the real GDP for the country being tested.

Figure 1: CAP and Export "Creation"

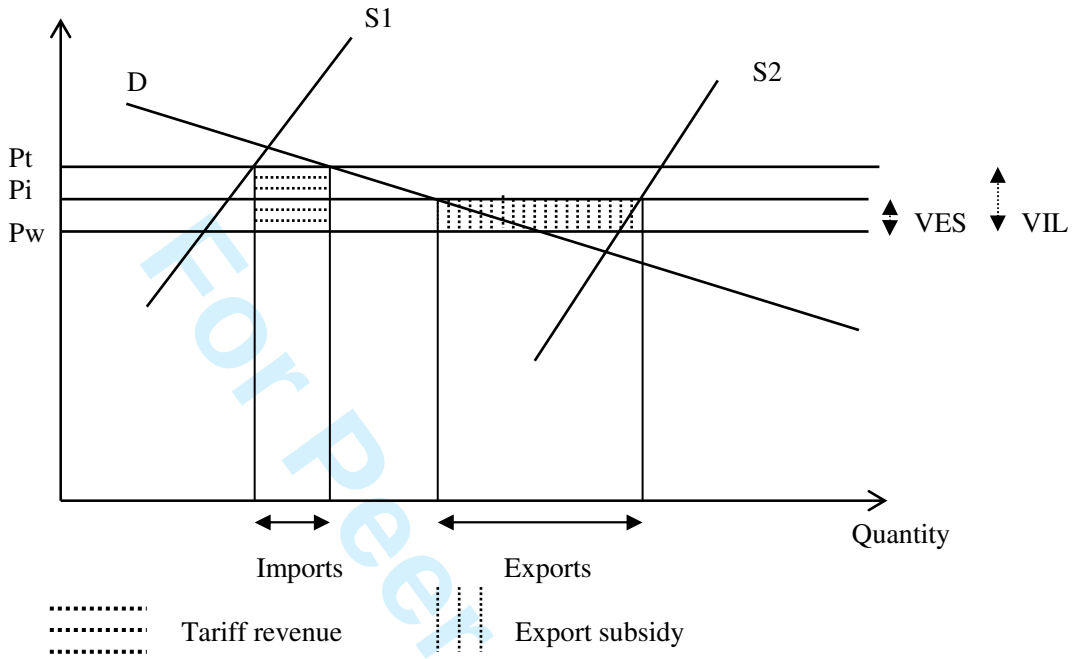
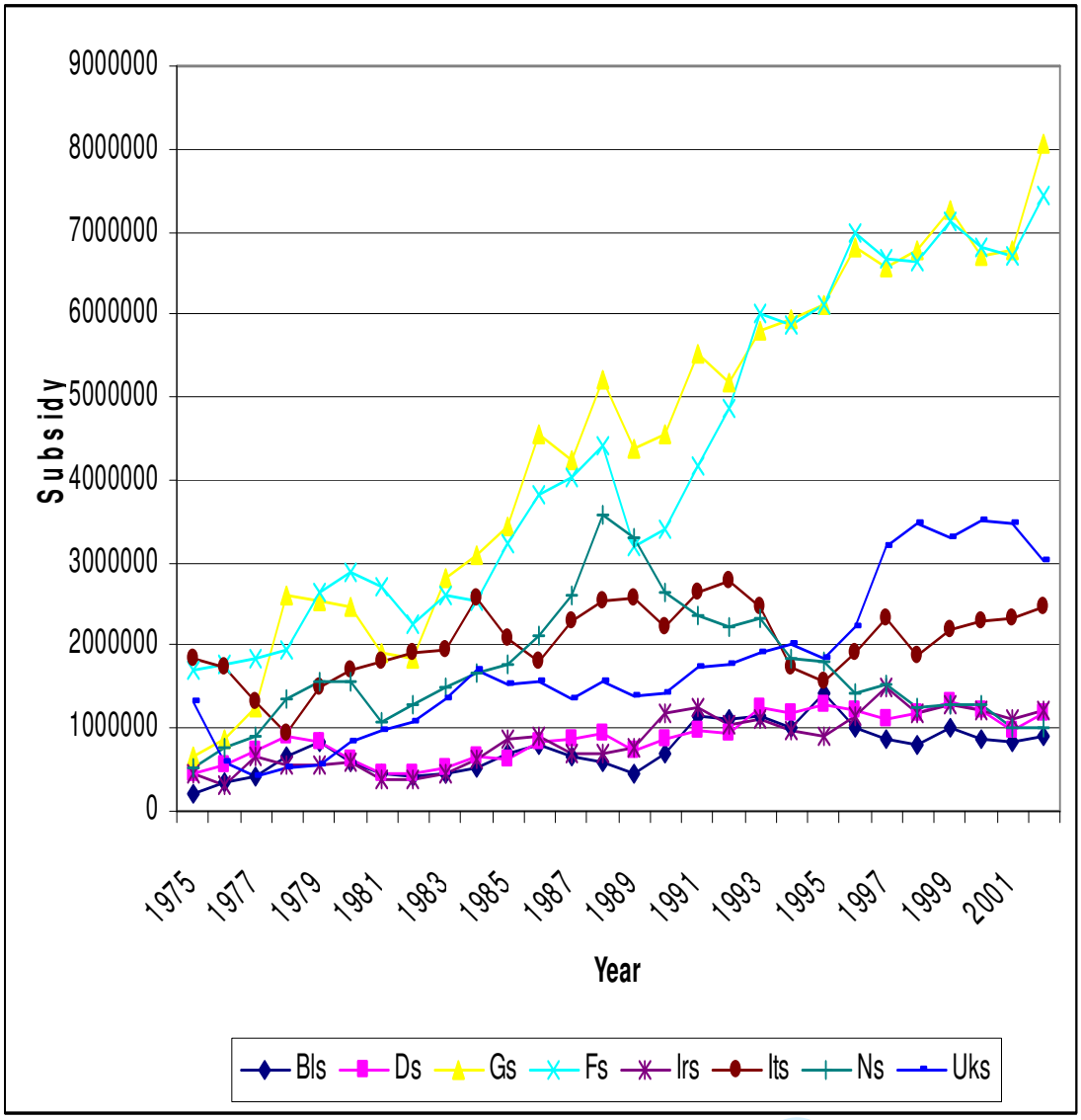
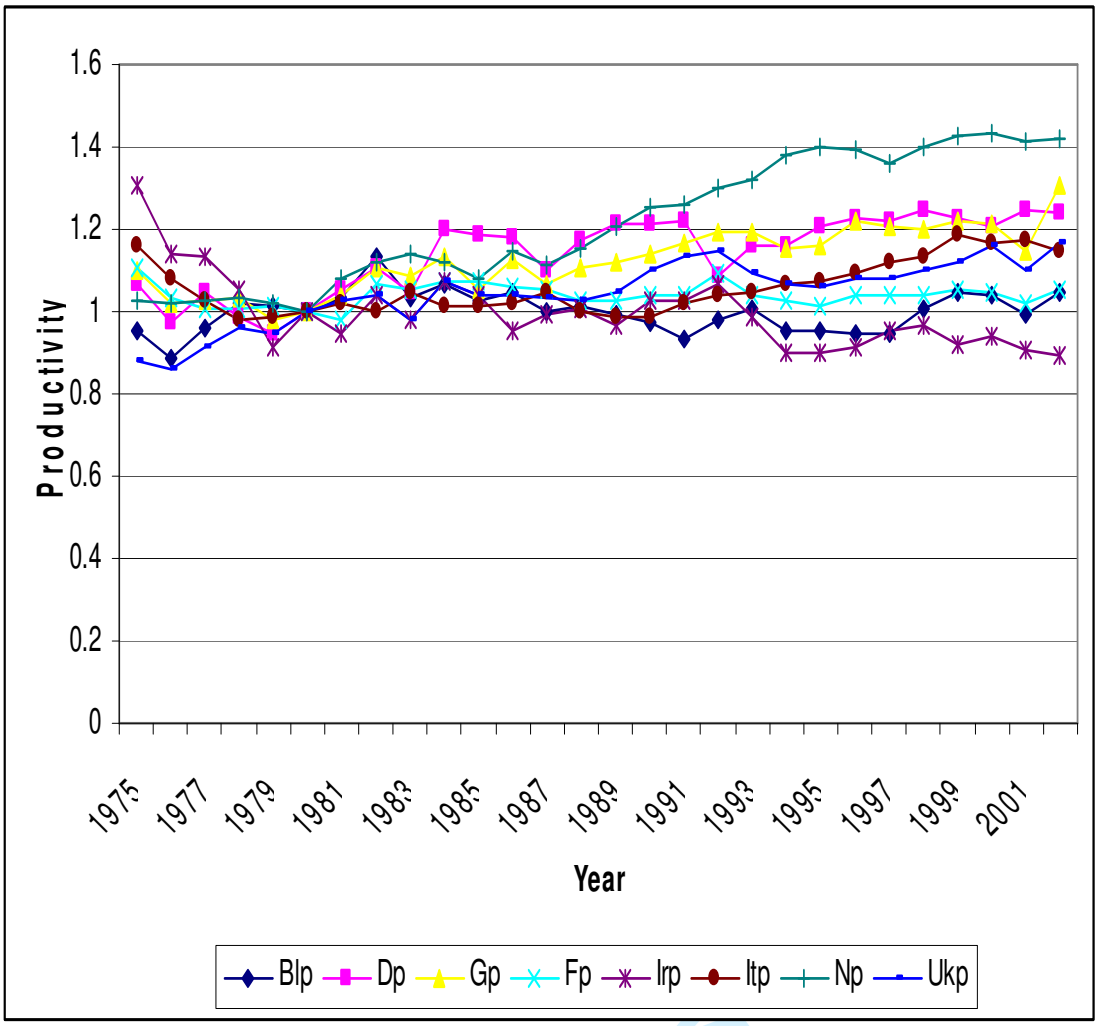


Figure 2 Subsidies in the EU



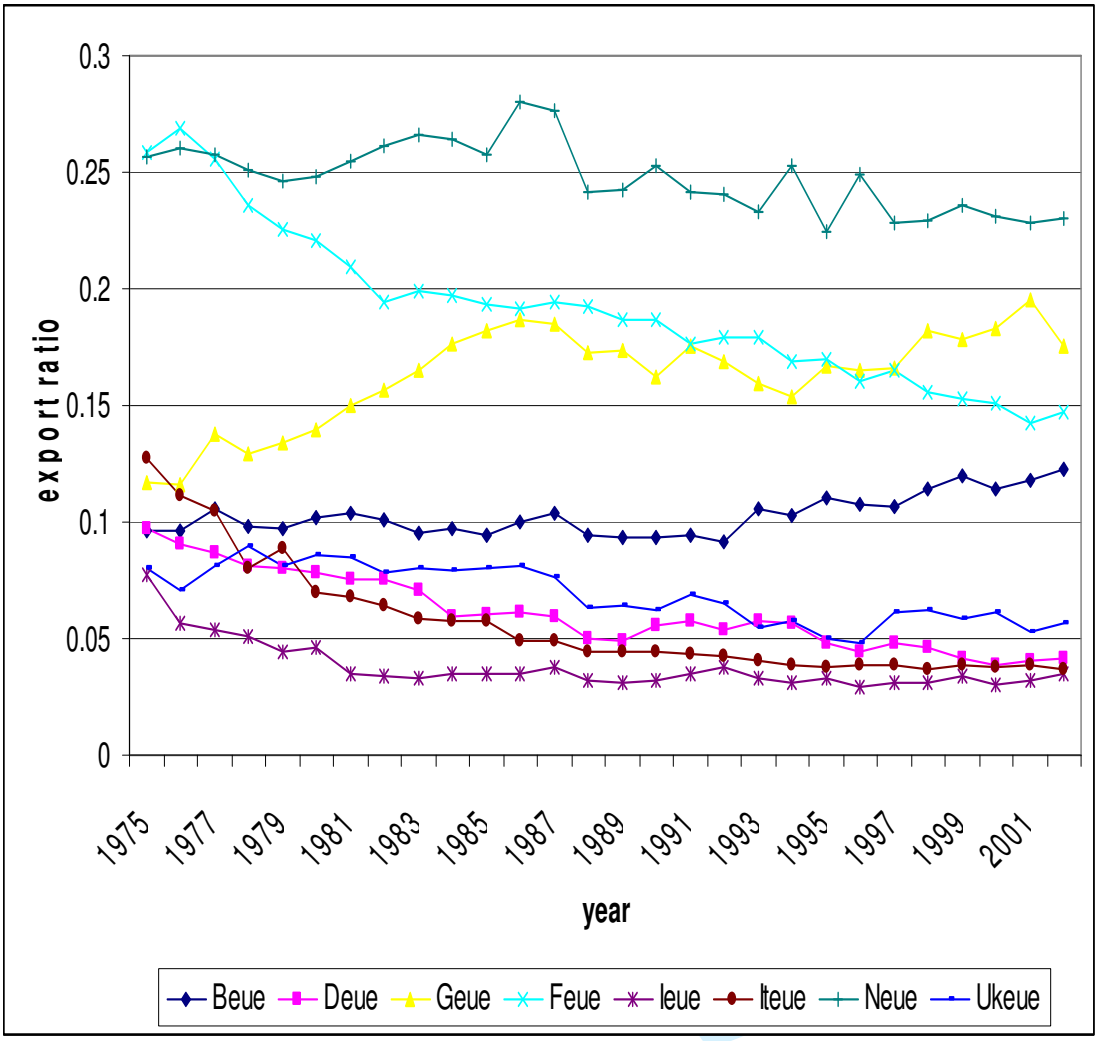
Notes: These are real subsidies (1980 prices) under the EAGGF guarantee scheme.

Figure 3 Productivity indexes for the EU



Notes: This productivity measure is the ratio between outputs and consumption of inputs.

Figure 4 Intra-EU exports



Notes: This index is the real intra-EU export level as a proportion of total real intra-EU exports.

ARDL Granger Causality Results

Table 1. Tests for Cointegration between Exports and Subsidies.

	S⇒E		E⇒S	
Country	t-test	F-test	t-test	F-test
Bel/Lux	-1.282	1.064	-3.106*	5.202**
Denmark	-1.592	1.371	-1.738	1.504
Germany	-0.210	6.473*	-3.344*	6.145*
France	-2.934**	5.580**	-1.105	1.090
Ireland	-2.703	6.998*	-1.151	1.205
Italy	-1.124	8.565*	-1.645	1.857
Netherlands	-1.892	2.625	-1.329	1.210
UK	-2.245	3.033	-0.953	3.550

Notes: S stands for subsidy and E for exports. Critical values are 5.73 (5%) and 4.78 (10%) for the F-statistic and -3.22 (5%) and -2.91 (10%) for the t-statistic test. * indicates significance at the 5% level, ** at the 10% level.

Table 2. Tests for Cointegration between Exports and Productivity

	Pr⇒E		E⇒Pr	
Country	t-test	F-test	t-test	F-test
Bel/Lux	-0.217	1.069	-2.430	3.092
Denmark	-1.413	1.069	-1.405	0.987
Germany	-2.633	6.314*	-2.055	2.123
France	-1.092	7.885*	-2.258	5.747*
Ireland	0.221	0.077	-3.524*	6.928*
Italy	-4.498*	12.417*	-2.574	3.339
Netherlands	-1.858	2.135	-1.113	0.641
UK	-3.199*	5.847*	-2.048	2.191

Notes: See Table 1 and 2. Pr is productivity.

Table 3. Granger Causality Tests between Exports and Subsidies

Country	Causal-ity	ECM (t-test)	$\sum \Delta e / s$	LM	J-B	Het	ARCH
Bel/Lux	S⇒E	-0.096(1.314)	0.105	1.801	1.720	1.997	0.126
	E⇒S	-0.577(3.183)*	0.133	0.316	0.439	0.106	0.373
Denmark	S⇒E	-0.329(1.591)	0.217	1.724	1.,156	0.389	0.293
	E⇒S	-0.193(1.727)	0.923	0.157	0.860	0.877	0.730
France	S⇒E	-0.372(2.934)*	0.455	1.568	1.430	1.385	0.008
	E⇒S	-0.072(1.105)	0.319	0.379	2.875	0.179	1.119
Germany	S⇒E	0.030(0.210)	0.068	1.744	0.695	0.833	0.321
	E⇒S	-0.577(3.344)*	0.019	0.122	0.536	3.693	0.391
Ireland	S⇒E	-0.521(2.793)*	0.019	2.081	0.697	0.118	0.019
	E⇒S	-0.475(1.151)	1.246	2.447	1.362	0.082	0.613
Italy	S⇒E	-0.198(1.424)	1.182	0.314	0.552	2.786	6.085
	E⇒S	-0.620(1.645)	0.038	0.004	1.579	0.772	0.044
Nether-lands	S⇒E	-0.240(1.801)**	0.698	1.752	1.564	0.696	3.300
	E⇒S	-0.133(1.329)	1.988	0.487	0.561	0.629	0.127
UK	S⇒E	-0.759(2.245)*	0.069	0.040	1.845	0.047	0.019
	E⇒S	-0.075(0.955)	0.349	1.371	0.801	1.323	0.007

Notes: Critical values for ECM (error correction term): 2.05 (5%) and 1.70 (10%). LM is the Lagrange Multiplier test for first-order autocorrelation, J-B is the Jarque-Bera test for non-normality (Chi-squared 2), Het is a LM based test for heteroskedasticity and ARCH is the test for ARCH(1). All follow the F-distribution, which has better small sample properties, except the test for non-normality which follows the chi-squared distribution. Columns 4 is a Wald test for the sum of the lagged explanatory variables. Critical values for chi-squared (1) are 3.842, For F(1,19) are 4.38 and F(1,24) is 4.26 (Test for heteroskedasticity only).

Table 4. Granger Causality Tests between Exports and Productivity

Country	Causality	ECM (t-test)	$\sum \Delta e / p$	LM	J-B	Het	ARCH
Bel/Lux	Pr⇒E	-0.013(0.217)	0.014	0.002	0.897	0.465	0.066
	E⇒Pr	-0.512(2.430)*	0.025	1.131	0.925	4.815	1.014
Denmark	Pr⇒E	-0.328(1.413)	0.144	2.681	2.191	0.884	0.512
	E⇒Pr	-0.204(1.405)	1.557	0.153	3.400	0.574	0.092
France	Pr⇒E	-0.162(1.092)	0.745	1.014	0.815	1.685	0.165
	E⇒Pr	-0.720(2.258)*	0.004	0.223	0.382	0.021	0.353
Germany	Pr⇒E	-0.223(2.631)*	1.496	1.659	2.126	0.412	0.005
	E⇒Pr	-0.477(2.051)*	0.323	0.199	0.439	0.171	0.132
Ireland	Pr⇒E	-0.031(0.221)	0.642	0.011	6.376	0.383	0.026
	E⇒Pr	-0.534(3.524)*	0.113	3.805	1.952	1.305	2.106
Italy	Pr⇒E	-0.586(4.559)	0.385	0.335	0.229	4.751	0.024
	E⇒Pr	-0.300(2.606)*	0.663	0.318	1.142	0.190	0.009
Nether	Pr⇒E	-0.347(1.858)	0.086	0.098	0.646	0.760	2.785
-lands	E⇒Pr	-0.097(1.113)*	1.725	0.541	0.341	2.775	0.833
UK	Pr⇒E	-0.687(3.199)*	0.726	0.411	0.909	0.325	0.330
	E⇒Pr	-0.284(2.048)*	0.027	0.072	1.030	0.514	0.006

Notes: See Table 3.

Table 5. Multivariate causality tests.

		Financial Support		Productivity	
Country	Causality	$\sum \Delta e / p$	$\sum \Delta y$	$\sum \Delta e / s$	$\sum \Delta y$
Bel/Lux	S/P⇒E	0.097	0.072	0.293	0.116
	E⇒S/P	1.527	0.249	0.686	0.280
Denmark	S/P⇒E	0.048	0.031	0.682	0.229
	E⇒S/P	3.231**	1.034	5.155*	1.224
France	S/P⇒E	0.043	1.213	0.158	0.161
	E⇒S/P	2.895	0.551	0.087	2.334
Germany	S/P⇒E	0.906	0.552	1.025	1.922
	E⇒S/P	1.453	2.377	0.738	0.610
Ireland	S/P⇒E	4.307*	0.441	1.684	0.226
	E⇒S/P	0.249	0.130	0.068	1.872
Italy	S/P⇒E	0.060	0.036	0.321	0.083
	E⇒S/P	0.360	0.340	1.829	1.094
Netherlands	S/P⇒E	0.402	0.008	0.056	0.239
	E⇒S/P	0.317	0.014	5.112*	3.906*
UK	S/P⇒E	0.242	0.372	0.265	1.521
	E⇒S/P	0.018	0.168	0.020	1.348

Notes: The third and fourth columns are the causality tests between exports and financial support, including both lagged variables in productivity (column 4) and GDP (column 5) (The results from the other variables in these tests are not included as they follow the same pattern as the results in the previous Tables). The final two columns are causality tests between exports and productivity, including both lagged variables in financial support and GDP.