TREES OR TROTTERS?

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A real options model is used to explain why Irish farmers have been slow to switch from traditional farming to forestry despite numerous government incentives. In the theoretical model our results depend on profits from traditional farming relative to forestry. Under reasonable parameterisations of this profit ratio we show that it is optimal for farmers to stay in farming for six years before switching to forestry. In a subsequent empirical dynamic panel data model, the error correction model also predicts that it would take about six years for a change in the profit ratio to fully affect the number of hectares planted.

Key words: error correction, forestry, panel data, real options

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The Irish government, since 1986, has been aggressively encouraging farmers to switch from traditional agriculture[1] to forestry. This switch has been promoted through a scheme of grants and premium payments initiated by the European Union (EU) under the Agricultural Development Programme for the West of Ireland – referred to as the "Western Package". The government's policy to increase forestry cover has been further influenced by the adoption of the Kyoto Protocol (see UNFCCC (1997) for details) in which national targets of greenhouse gas emission levels are established for participating countries. Significant attention has begun to focus on the ability of the agricultural/forestry sector to reduce the level of greenhouse gases through abatement and sequestration strategies (see for example, McCaul and Schneider (2000) for the US, Behan and McQuinn (2003) for Ireland). Currently, Ireland at 9% has the lowest percentage of land covered by forestry in the EU. The government's strategic plan for forestry has the objective of increasing forest cover to 17% by 2030 (Department of Agriculture Food and Forestry (1996)). This implies a target of a national annual afforestation rate of 20,000 hectares (ha). Despite the level of aid given to farmers to encourage them to plant trees, the national annual average private afforestation rate has increased from almost less than 1,000 ha per annum in 1986 to a little over 14,000 ha per annum in 2001. This is 30% below he desired government target. In this paper, we ask why are Irish afforestation rates below target and what can the government do to encourage farmers to meet this objective?

In order to address these questions real options theory to analyse the farmer's production/investment decision and to motivate a statistical model for afforestation rates. Under realistic parameterisations of the theoretical model, we show that it is optimal for farmers to remain in traditional agriculture for approximately 6 years before switching to forestry. Increasing the present value of a stream of profits from forestry relative to that of traditional agriculture (we label this the *profit ratio*) reduces waiting time. Thus, one might expect a positive relationship between the numbers of hectares of trees planted and the profit ratio. The statistical model uses dynamic panel data methods that allow for cross sectional heterogeneity in the long-run cointegrating vectors and in the dynamics associated with short-run deviations from these cointegrating vectors. We find that a 1% increase in the profit ratio leads to a 2.2% increase in the afforestation rate in the long-run and that it takes about 6 years for full adjustment to occur. The econometric results seem to conform to our predictions from the real options model. Our results indicate that the Irish government would need to increase the profit ratio by approximately 20% to increase the number of hectares planted by farmers from 14,000 ha per annum to the target of 20,000 ha per annum.

Background

Since the independence of the Irish State in 1921 until the mid 1980s the number of hectares of forest planted per annum was small and has been almost exclusively public i.e. conducted by state run agencies. Given an average afforestation rate of 5,000 ha per annum, forest cover had only increased from 1 to 5 percent over the period 1921 to 1980. It was not until the 1980s that private planting by farmers began to significantly contribute to the level of forest cover. A more aggressive approach was adopted by the national government enhanced by funds provided for forestry by the then EEC ("Western Package" in 1981 and Regulation 297/85). Forestry was promoted as a profit generating economic activity. Given this stated policy shift, a series of financial incentives, grants and premia, were introduced at a national level to encourage farmers to consider forestry as an alternative farm enterprise. The values, in euro, of planting grants and premia are presented in Table 1. The planting grants and premia have increased by over 300% since 1986.

The forestry grant is paid in two instalments. The first instalment is paid in the first year after the plantation is established and it amounts to 75 percent of the total grant aid. The remaining 25 percent of the grant is paid after four years, when the plantation is assessed as to whether it complies with the Irish Forest Service's[2] standards in terms of stocking levels, fertility of the plantation (level of nourishment), fencing, drains, formative shaping etc. The forestry premium is paid to farmers annually, for a period of 20 years. Under current legislation, farmers are obliged to replant their land, which implies that planted land is bound in forestry in perpetuity. The premium is not paid for reforestation. There are also additional schemes, which the farmer-forester can avail of such as a road construction grant and reconstruction of woodlands scheme.

In Figure 1 we present afforestation rates for five regions in Ireland over the period 1986-2001.[3] The planting conducted by farmers has become the key driver for forestry expansion in recent years, with farmer planting currently accounting for 93 percent of total plantings. While there has been a steady increase in regional afforestation rates since 1986, there have been peaks and troughs. These swings broadly coincide with major changes in forestry premia and reforms under the EU's Common Agricultural Policy (CAP). However, despite the financial incentives, the uptake by farmers has not been sufficient to meet the national target of 20,000 ha per annum.

We present the profit ratio in Figure 2 (see the Appendix for details on the construction of this ratio for each region). The major increase in the ratio since 1994 is due to two main reasons. The first is that the forestry premium was greatly increased in 1994 under the EU Forestry Development Programme (see table 1). The second is that cattle prices fell significantly over the 1994-1999 period due to the BSE crisis. There would appear to be a similar general upward trend in both regional afforestation rates and the profit ratios. We motivate such a relationship using real options theory in the next section.

The Real Options Model

For most countries in the EU and North America it is the issue of reforestation (planting on clear felled land) that is primarily of interest to policymakers. In the Republic of Ireland however, the first clear fell of farmer-owned forests is expected to occur beyond 2020. Therefore, in this paper we wish to model a farmer's decision to switch from traditional agriculture to forestry. Qualitative studies suggest that Irish farmers are reluctant to plant their land with trees and two main reasons are cited (see by Gardiner and Ni Dhubhain (1994), Gillmor (1998), Clinch, McCormack and O'Leary (2000), Frawley and Leavy (2001)). The first is that profits from forestry tended to be smaller than those in agriculture. The second is farmers were worried about the costs and risks associated with forestry and the long-term nature of forestry investment. We try to capture these findings with a suite of real options models.

Consider a farmer's decision to switch from traditional agriculture to forestry. We assume that the farmer is a profit maximizer and operates in a competitive market with certainty. At time t, let A and F be profits from traditional agriculture and forestry respectively. For simplicity we assume that profits from traditional agriculture and forestry grow at constant rates, μ and λ, respectively. The farmer's constant discount rate is r ($r>\lambda$ and $r>\mu$ by assumption). We assume that the farmer faces three options with regard to his/her production decision and chooses the option that maximizes the present discounted value. The first option is to stay in traditional agriculture forever. The value of land per hectare for option 1, $V^1(0)$, at time t=0 is given by

$$(1) \qquad V^1(0) = \int_0^\infty Ae^{-(r-\mu)t}dt = \frac{A}{r-\mu}$$

The second option is to start in traditional agriculture and then switch to forestry at an optimal time T^* and remain in forestry forever after that time. In this case the investment decision is deemed irreversible given that farmers are obliged under Irish law to replant their land after its clear felled (see Tegene, Wiebe and Kuhn (1999) and Behan and Wiemers (2003)). There is an annualised cost C per hectare associated with this irreversibility. This is due to the fact that the value of forestry land is less that that of agricultural land. The value of land per hectare for option 2, $V^2(0)$, at time t=0 is given by

$$(2) \qquad \begin{aligned} V^2(0) &= \int_0^{T^*} Ae^{-(r-\mu)t}dt + \int_{T^*}^\infty Fe^{-(r-\lambda)t}dt - \int_{T^*}^\infty Ce^{-rt}dt \\ &= \frac{A}{r-\mu}\left[1-e^{-(r-\mu)T^*}\right] + \frac{F}{r-\lambda}\left[e^{-(r-\lambda)T^*}\right] - \frac{C}{r}\left[e^{-rT^*}\right] \end{aligned}$$

The third option is to convert idle land to forestry and remain in it forever. The value of land per hectare for option 3, $V^3(0)$, at time t=0 is given by

(3) $$V^3(0) = \int_0^\infty Fe^{-(r-\lambda)t}dt - \int_0^\infty Ce^{-rt}dt = \frac{F}{r-\lambda} - \frac{C}{r}$$

We calculate the value of the three options using parameters from Behan and Wiemers. The value of profits per hectare for dry stock farming and forestry is estimated to be €128 and €390 respectively for 2001. We assume that only dry stock farming should be taken into consideration as it is seen as the agricultural enterprise most likely to compete with forestry. In the last decade, profits from traditional agriculture have been more or less constant. We assume that the growth rate μ will be zero. In contrast, profits from forestry have grown at fast and fluctuating rates over the 1986-2001 period. This has been due to the aggressive intervention by the government over the same period. Following discussions with industry representatives (Coillte[4], Forest Service, Teagasc[5] forest advisors) profits from forestry are expected to grow at more modest rates. We assume that the growth rate λ will be 2%. The annualised difference in the value of agricultural and forestry land is estimated to be €320 per hectare (see Behan and Wiemers). The discount rate is assumed to be 5% per annum.[6] The discounted values of options 1, 2 and 3 are €2440, €6750 and €6600 respectively. Under this parameterisation, discounted profits are maximized using option 2. In this case, it is optimal for a farmer to wait 6.3 years before switching to forestry. Increasing the profit ratio reduces this waiting time.

The Statistical Model

The increased focus of Irish government policy on afforestation has also lead to some recent empirical studies exploring the factors determining Irish forestry levels. Barrett and Trace (1999) investigate the relationship between hectares of forest planted and the annual forestry premium, agricultural subsidies net of Rural Environment Protection Scheme (REPS) payments, forestry land prices and relevant CAP policy measures. The fact that none of these variables are found to be statistically significant is probably due to the small sample size used in the analysis.[7] McCarthy, Matthews, and Riordan (2002) using panel data analysis relates hectares of forest planted to the forestry grant and premium levels, forestry margins, agricultural margins and area entered in REPS. All variables are found to be statistically significant except agricultural margins. The authors suggest that forestry may be planted on marginal agricultural land, and therefore is relatively impervious to agricultural margins.

International empirical investigation of land allocation between forestry and traditional agriculture is characterised by a paucity of efforts. Alig, Adams and McCarl (1998), in a review of agriculture sector models, comment, "sector models used to analyse policies have not included full land base interaction between the forest and agriculture sectors." In presenting an optimal control model of carbon sequestration and energy abatement, Sohngen and Mendelsohn (2003) state that a "dynamic integrated model that captures both forestland and agricultural land is clearly needed". What approaches do exist are typified by the net present value approach of Alig, Adams and McCarl, where area allocation is determined by the relative present value of future agriculture and forestry gross margins. These approaches, in line with those of Barret and Trace, McCarthy, Matthews, and

Riordan, and Behan and McQuinn, assume a single period instantaneous adjustment by producers to changing market and policy signals. Such a static approach is particularly inappropriate in an Irish context where qualitative research testifies to the reluctance of Irish producers to consider forestry as an alternative to traditional agricultural practices. As noted previously, Gardiner and Ni Dhubhain, Gillmor, Frawley and Leavy, and Clinch, McCormack and O'Leary all present survey data detailing the cultural reticence of Irish producers in adopting farm forestry. Producer behaviour is likely to be characterised by a multi-temporal adjustment to market and policy signals – dynamics, therefore, we contend, should be a key component of any area response function. Using techniques developed by Pedroni (1999, 2000), we present a dynamic panel data model that investigates the short and long run relationships between afforestation rates and the profit ratio.

Recall, that the real options models suggests that afforestation rates at time t per region i ($Y_{i,t}$) depend on the profit ratio per region ($X_{i,t}$) and that changes in the profit ratio may take time to take effect. Thus, we hypothesise that the following error-correction model should adequately capture this relationship

$$(4) \qquad \Delta Y_{i,t} = -\alpha\left(Y_{i,t-1} - \beta_i X_{i,t-1}\right) + \delta\Delta X_{i,t} + e_{i,t} \quad t = 1,...T \quad i = 1,...N$$

There are T=16 annual observations covering the period 1986-2001 and N=5 regions. We follow Pedroni (1999,2000) and allow the error term to include fixed effects and allow the long-run slope coefficients to vary across regions. We can test whether the latter are equal using Pedroni (2000).

The group mean panel t-test statistics developed by Pedroni (1999) allow one to test for the null of a unit root against the alternative hypothesis of a stable root that does not assume a common value across regions. The tests are based on the panel group mean fully modified OLS estimator and are statistic number 4 in Table 1 in Pedroni (1999). The results of this test presented in Table 2, suggest that both series are I(1). We use a similar group mean panel t-test statistic to test for cointegration between the two variables. The result of the test also presented in Table 2 suggests that afforestation rates and the profit ratio are cointegrated.

The estimated long-run slope coefficients are presented in Table 3. The t-statistics for H_0: β_i=0 are presented in the round parentheses. The tests are based on the group mean panel fully modified ordinary least squares estimator in Pedroni (2000). The long-run coefficients are all significantly different than zero at conventional levels. The group estimate is equal to 2.2. We test the H_0: β_i =2.2 for all regions and the t-statistics are presented in the square parentheses in Table 3. We cannot reject the null hypothesis that all of the long-run coefficients are equal to 2.2 at conventional levels. This implies that a 1% increase in the profit ratio leads to a 2.2% increase in the number of hectares planted in the long-run.

We estimate two versions of the short-run error-correction model equation (4) to determine how many years it takes to adjust to the long-run. In model 1 we allow for the current change in the profit ratio to enter the short run dynamics in equation (4) and in model 2, we allow for the change in the profit ratio lagged 1 period to enter the short run dynamics in equation (4). The results are presented in Table 4 where the Newey-West (1987) t-statistics are in parentheses and the fixed effects dummy variables are represented by their regional names. Our results indicate that the change in the profit ratio lagged a period fits the data best. The coefficient on the error-correcting term is very significant and suggests sluggish adjustment to the long-run. The impulse response of the numbers of hectares planted following a 1% increase in the profit ratio is presented in Figure 3. It takes approximately 6 years for most of the adjustment to take place. Therefore, the econometric results would appear to conform to the results of the real options model presented in (1) – (3).

The regional fixed effects dummy variables are jointly significantly different than zero at the 1% level. The individual coefficient for the west and south-west regions are the largest. Other things being equal one might expect this, as soil quality is relatively poorer, particularly, in the western region and thus farmers are more likely to plant trees. This also reflects the results from surveys by Gardiner and Ni Dhubhain and by Frawley and Leavy suggesting that a large proportion of farmers would consider forestry only on land that cannot be used for any other purpose.

Conclusion

For nearly twenty years the government of the Republic of Ireland has been aggressively promoting forestry as a private enterprise. The desire to increase forestry cover has been stimulated further by the adoption of the Kyoto Protocol in 1997. Increased rates of afforestation can positively affect the net emissions balance as carbon sequestered may be set off against emissions of carbon from the rest of the economy. Despite the large increases in forestry grants and premia in the Republic of Ireland, the country has very low levels of forest cover and current afforestation rates are 30% below government targets.

We motivate a statistical model relating afforestation rates to the ratio of profits from forestry to those of traditional agriculture using real options theory. We show that under reasonable parameterisations farmers who maximize the discounted present value of future profits will wait for about six years before switching from traditional agriculture to forestry. In this model raising the profit ratio will reduce the waiting time. Using panel data an estimated error-correction model suggests that it takes about six years to fully adjust to a shock to the profit ratio. Our results also indicate that the Irish government would need to increase the profit ratio by approximately 20% to increase the number of hectares planted by farmers from 14,000 per annum to their target of 20,000 per annum.

Appendix A

The profit ratio is a comprehensive ‘catch all’ variable seeking to capture the competition between agriculture and forestry for an extra hectare of land. It is calculated for each region as a ratio of discounted forestry profits per hectare to discounted agricultural profits per hectare. The discounting period is 40 years, since it is assumed that it takes this amount of time from planting to clear fell for most plantations in Ireland. The discount rate is 5 percent, as commonly used in the literature for forestry calculations. The average ex post real interest rate on long-term Irish government bonds has been 5% over the 1986-2001 period.

The discounted forestry profits per hectare are calculated as all revenues that arise from forestry over the rotation period minus costs over 40 years. The revenues include forestry premia, revenue from thinnings and clear fell. Only data for 2000 was available for revenues from thinnings and clear fell. Therefore, a time-series for 1986-1999 is constructed by applying a timber price index to the 2000 levels. For the first four years all costs (plants, fencing, vegetation control, fertiliser, planting, ground preparation) are covered by the forestry grant and thus are excluded from all calculations since they cancel each other out. After four years there are maintenance costs. Only data for 2000 is available for costs associated with forestry (this was provided by the Forest Service). Therefore, a time-series of maintenance costs for 1986-1999 is constructed by applying the GDP deflator index to the 2000 level. The discounted forestry profits per hectare are not regionally adjusted, as there is no regional breakdown of forestry revenues and costs.

Discounted agricultural profits per hectare are calculated as a weighted average of the discounted profits per hectare for dairy, cereals, suckler cows, other cattle and sheep enterprises. The discounting period is also 40 years. The land areas for each of these enterprises are used as weights. In the case of livestock, the area was divided amongst enterprises according to the proportion of the national herd accounted for by each enterprise's herd size. We also add payments from the Rural Environment Protection Scheme (REPS).[8]

Each agricultural profit is calculated as the difference between revenues and variable costs on a per hectare basis. Revenues include both market revenue and subsidies provided under the CAP. These subsidies include: arable aid, various livestock premia, and extensification and headage payments. The costs comprised of various costs of production, as well as an opportunity cost of labour. The opportunity cost is included to account for the fact that as forestry is less labour intensive than farming, the possibility of additional income from off-farm employment for farmers turned foresters exists. The opportunity cost is calculated by applying the national minimum wage per hour to the surplus requirements of hours required for farming over that of forestry. The calculated amount of hours required for both enterprises is obtained from the Teagasc published 'Handbook for Farm Planning'. All agricultural revenues and costs with the exception of the opportunity costs comes from both the

Irish Central Statistics Office (CSO) and the Teagasc conducted National Farm Survey (NFS). For more on the NFS see Heavey, Roche and Burke (1997).

The discounted agricultural profits per hectare are regionally adjusted. Extensification and headage payments are adjusted on the basis of the proportion each region takes in the national envelope.[9] For instance, the greatest proportion of the extensification envelope is allocated to the western regions of the country, where the average stocking density is below the national average. These regions are also the main recipients of headage payments, since greater area in those regions qualifies as disadvantaged area. Livestock density is also subject to regional adjustment by a regional livestock adjustment coefficient. Regional adjustments for agricultural revenues and costs are made on the basis of regional data from the NFS.

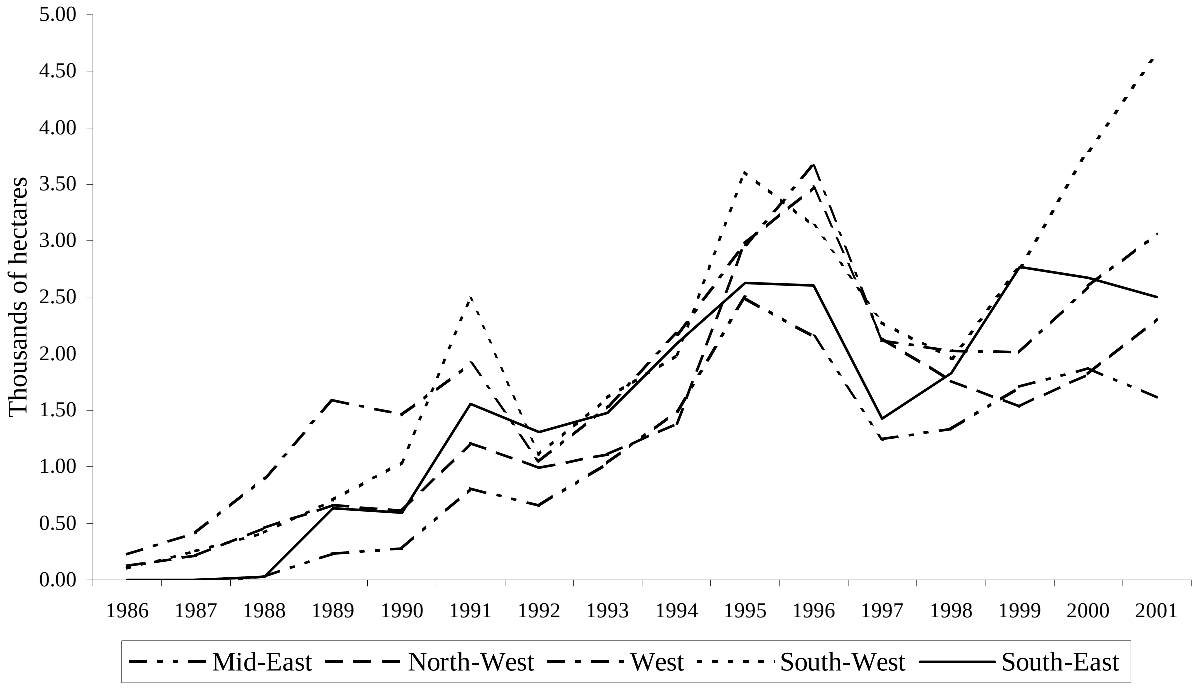

Figure 1. The number of hectares of Irish forestry planted by farmers

Figure 2. The ratio of profits from forestry to that of traditional farming

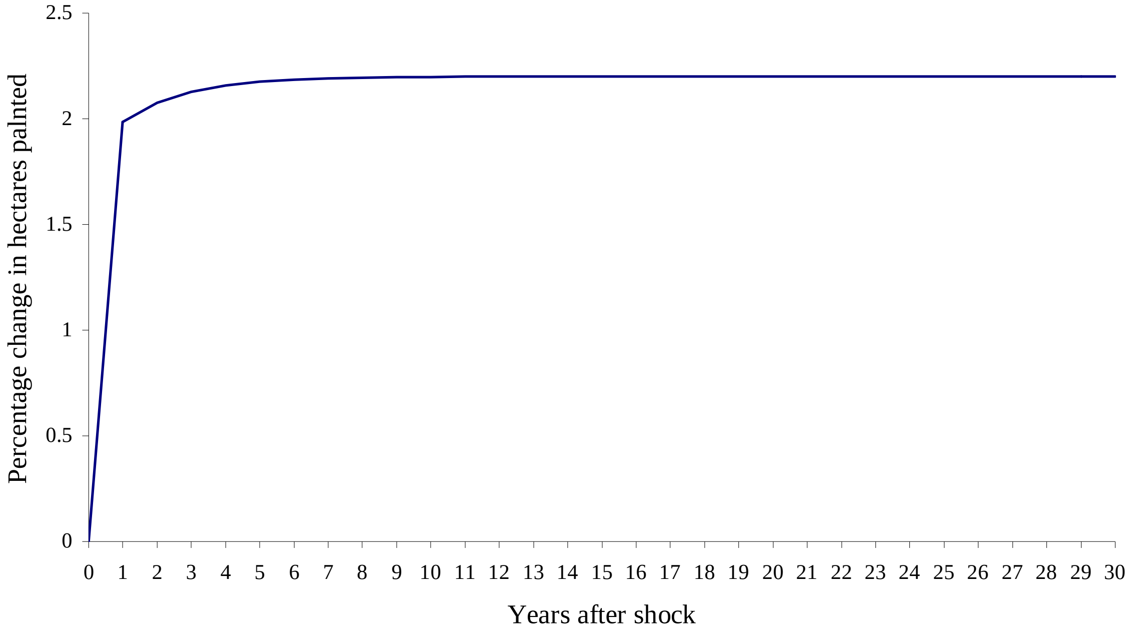

Figure 3. The impulse response of the numbers of hectares planted following a 1% increase in the profit ratio

Table 1. Irish Grant and Premium Payments Per Hectare for 20% Diverse Conifer Plantings on Enclosed Land (euro)

Years	Grant	Premium
1986-1988	630	94
1989-1991	1,397	109
1992-1993	1,397	127
1994-1997	1,905	286
1998-1999	2,286	343
2000-2001	2,857	391

Source: Afforestation Grant and Premium Schemes, Forest Service, Department of the Marine and Natural Resources

Table 2. Group Mean Panel Unit Root and Cointegration Tests

Test	Variable	Test-statistic
Panel Unit Root Test	Afforestation rate	-1.47
Panel Unit Root Test	Profit ratio	-0.65
Panel Cointegration Test		-3.11*

Notes: The tests are based on the panel group mean fully modified OLS estimator and are statistic number 4 in Table 1 in Pedroni (1999). A * indicates significance at the 1% level.

Table 3. Group Mean Panel Estimator of the Cointegrating Coefficient

	Individual tests
Mid-East	1.52
	(2.49) [-1.13]
North-West	1.80
	(2.19) [-0.49]
West	1.89
	(2.88) [-0.48]
South-West	3.18
	(4.68) [1.44]
South-East	2.53
	(3.32) [0.43]
	Group test
	2.18
	(6.95) [-0.10]

Notes: The t-statistics for H_0: $\beta_i = 0$ are in the round parentheses and the t-statistics for H_0: $\beta_i = 2.2$ are in the square parentheses. The tests are based on the panel group mean fully modified OLS estimator in Pedroni (2000).

Table 4. Panel Error-correction Model

	Model 1	Model 2
$\left(Y_{i,t-1} - 2.2 * X_{i,t-1}\right)$	-0.36	-0.42
	(-3.80)	(-5.13)
$\Delta X_{i,t}$	0.25	
	(0.60)	
$\Delta X_{i,t-1}$		1.06
		(1.82)
Mid-East	-0.03	-0.08
	(-0.26)	(-0.54)
North-West	0.07	0.05
	(0.44)	(0.31)
West	0.28	0.29
	(2.44)	(2.29)
South-West	0.43	0.45
	(2.87)	(3.13)
South-East	0.24	0.26
	(2.36)	(2.47)

Notes: The Newey-West (1987) t-statistics are in parentheses. The fixed effects dummy variables are represented by their regional names.

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Endnotes

[1] In Ireland traditional agriculture is mainly dairy and livestock.

[2] Based in the Department of Communications, Marine and Natural Resources.

[3] These regions are the mid-east, north-west, west, south-west and south-east. They are used for regional classification by the Irish Central Statistical Office (CSO).

[4] Coillte Teoranta (The Irish Forestry Board) is the leading Irish company operating in forestry and related businesses.

[5] Teagasc is the Irish Agriculture and Food Development Authority.

[6] The average ex post real interest rate on long-term Irish government bonds has been 5% over the 1986-2001 period.

[7] The number of observations was 17.

[8] REPS is a co-financed scheme between the Irish Exchequer and the EU designed to reward farmers for carrying out their farming activities in an 'environmentally friendly' manner. In 2002, over €200 million was paid out to Irish farmers through the scheme.

[9] The national envelope is a separate discretionary fund available to the national exchequer for expenditure within agriculture. It is accumulated by reducing the total amount of direct payments receivable/payable by a certain proportion.