www.esri.ie

Working Paper No. 357

October 2010

An Estimate of the Value of Lost Load for Ireland

Eimear Leahy and Richard S.J. Tol[a,b c]

Abstract: This paper estimates the value of short term lost load in the all island electricity market which includes the Republic of Ireland and Northern Ireland. The value of lost load, also known as the value of security of electricity supply, is inferred using a production function approach. Detailed electricity use data for the Republic of Ireland allows us to estimate the value of lost load by time of day, time of week and type of user. We find that the value of lost load is highest in the residential sector in both the Republic of Ireland and Northern Ireland. Our results can be used to advise policy decisions in the case of supply outages and to encourage optimum supply security. In the context of this study short term is taken to be a matter of hours rather than days or weeks.

Corresponding Author: eimear.leahy@esri.ie

Key words: Value of lost load; Ireland

[a] Department of Economics, Trinity College, Dublin, Ireland
[b] Institute for Environmental Studies, Vrije Universiteit, Amsterdam, The Netherlands
[c] Department of Spatial Economics, Vrije Universiteit, Amsterdam, The Netherlands

An Estimate of the Value of Lost Load for Ireland

1. Introduction

The value of lost load is the average willingness of electricity consumers to pay to avoid an additional period without power. In an efficient market, it should be equal to the wholesale peak price of electricity. The value of lost load would then affect decisions regarding investment in new generation capacity and closure of older, less efficient plants. Due to regulation in the Irish electricity market, customers cannot express their willingness to pay. Thus, the value of lost load has to be inferred.

According to Lyons et al. (2007), it appears that peak and reserve capacity is undersupplied in Ireland and Bazilian et al. (2006), Lyons et al. (2007) and Malaguzzi Valeri and Tol (2006) are of the opinion that the possibility of supply shortages is real, although the risk is smaller now due to the recession. As Ireland's electricity supply becomes increasingly variable, primarily because of the growing share of wind power in total power generation, capacity management and reward is extremely important. New forms of electricity demand, such as electric and hybrid vehicles, as well as increased interconnection will also lead to variability in demand and supply. An accurate and up to date assessment of the value of lost load is therefore essential to inform future planning.

This paper updates Tol (2007) which is the first and only published empirical estimate of the value of lost load for the Republic of Ireland (ROI). The main advantage of this paper is that access has now been provided to data on the time profile of electricity use per type of user in ROI. Whereas Tol (2007) assumed that the probability of a brown-out[1] is constant across consumer groups, we can now estimate which users would be hardest hit by such an event. We use this data to estimate the value of lost load in ROI between 2001 and 2008. We also estimate the value of lost load for Northern Ireland (NI) between 2000 and 2007. Thus, this paper constitutes a substantially refined estimate of the value of lost load in the all island market.

In 2007 the regulatory authorities of the Single Electricity Market[2], the Commission for Energy Regulation (CER) and the Northern Ireland Authority for Utility Regulation

[1] A brown-out is defined as a condition where the voltage supplied to the system falls below the specified operating range, but above zero volts. A black-out is a total loss of electrical power in a region.
[2] The Single Electricity Market is a joint electricity market between the Republic of Ireland and Northern Ireland.

(NIAUR), set the value of lost load at €10/kWh based on the estimated peak price of planned electricity capacity (CER and NIAUR, 2007). The stated reasoning is rather unrealistic since it assumes that planned capacity will always equal desired capacity. The value has been re-estimated on an annual basis by using the previous year's value and adjusting it by applying the weighted average of the year-on-year increase in the Irish Harmonised Index of Consumer Prices (HICP) and the UK HICP.[3] Using this method, CER and NIAUR (2009) find that the value of lost load for 2010 is €10.27/kWh.

The paper continues as follows. Section 2 presents the methodology and Section 3 the data. The results are discussed in Section 4 and Section 5 provides a discussion. Section 6 concludes.

2. Methodology

The value of lost load can be estimated in three ways. The first is that used by Beenstock et al. (1998) which relies on consumer surveys and is based on stated preferences. Beenstock et al. (1998) find that the value of lost load for Israeli households was $7/kWh in 1990 prices. Since no Irish data of this kind exists, this method is unavailable to us. Corwin and Miles (1978) estimated the value of lost load using cost estimates from previous supply outages. The underlying assumption is that the past and the future are similar, which is not appropriate for Ireland given the rapid economic and structural changes that have taken place. The third alternative, which is employed in this paper, is based on estimates of production functions. Production functions imply demand functions but additional assumptions are required such as rationality of economic agents and divisibility of goods and services. Typically, production functions are estimated for a year as a whole, and may not be appropriate for an assessment of the impact of an event such as electricity interruptions for a few hours. Nonetheless, the production function approach is adopted here as the only viable option given data availability.

The production function approach relates electricity use to firm output, or in the case of households, the value of time spent on non paid work. This technique enables us to estimate the value of lost load by dividing Gross Value Added (GVA) (in € millions) in a specific sector by the amount of electricity in (Gigawatt hours (gWh)) used. This will

[3] The Irish HICP is given a weight of 2/3 and the UK HICP is given a weight of 1/3. Year on year increases are based on July estimates.

give the value per kilowatt hour (kWh) that this sector generates, roughly equal to the value that would be lost in the case of a brown-out. In estimating VoLL for NI we follow the exact methodology of de Nooij et al. (2007) and Tol (2007). For ROI, more detailed data allows us to extend the technique so that more detailed results can be generated. de Nooij et al. (2007) found that the average VoLL in the Netherlands in 2001 was under €9/kWh. Tol (2007) found that the average VoLL in Ireland in 2005 was much higher; €40/kWh.

For NI, we assume that each sector's production function is linear and that companies are able to shift production within the year. Thus, the time at which the brown-out occurs is not important, but of course some production will be lost due to the brown-out. This assumption is a reasonable one for most activities. Another assumption is that the duration of the electricity outage does not matter. This is also reasonable as any brown-outs that could occur in NI are likely to be for short periods. For households we define the value of lost load as the value of time spent on non paid work divided by electricity used. We assume that all activity stops when there is no electricity. Thus, an hour without electricity is an hour of time lost. This seems a generous assumption, but risk and annoyance are not taken into account. The value placed on time spent on non paid work varies with electricity use by time of day. Exelon (2007) shows that in the UK 44% of household electricity is used during the day, 35% in the evening, and 20% at night. For NI we estimate the value of time spent at non paid work by day, evening and night for midweek days and weekend days.

For ROI, we have more detailed data so we employ a slightly more elaborate method. The ROI data consist of the electricity profiles of the residential, industrial and commercial sectors for each hour of 2001. We derive the proportion of electricity used by each sector at each hour and use it as a proxy for the proportion used by each sector in each hour in later years. For the industrial and commercial sectors, we estimate the annual average value of 1 kWh of electricity as before. Since we do not know the value added by the industrial and commercial sectors per day and hour, we cannot derive the value of lost load per time of day or year. However, we can estimate the total hourly value of electricity by multiplying the average value of 1 kWh of electricity by the amount of electricity used.

To evaluate lost load in the residential sector, we incorporate data from the 2005 Time Use in Ireland Survey (ESRI, 2005). Using this data we can assess the activities in which people are involved over two 24 hour periods; one midweek and the other weekend. For those who are not at home or at home but asleep, the cost of a brown-out is zero. For those who are working from home we assume that the opportunity cost of time spent on non paid work is equal to the average wage after tax. For those at home and neither working nor asleep, the opportunity cost of time spent on non paid work is equal to half of the average wage as in de Nooij et al. (2007) and Tol (2007). Thus, the opportunity cost varies throughout the day and between midweek and weekend days. As we have data on the profile of household electricity use, we can find hourly values of lost load by dividing the value of time spent on non paid work in that hour by the amount of electricity used.

There are of course limitations associated with the use of production functions to estimate the value of lost load. One drawback is that additional assumptions are required such as rationality of economic agents and divisibility of goods and services. Also, production functions are usually estimated on an annual basis and thus may not be appropriate for estimating the impact of hourly electricity interruptions. We are unable to account for restart time in businesses after an outage or annoyance in households caused by a supply interruption.

3. Data

Estimates of annual electricity use in NI are taken from the Department of Energy and Climate Change (DECC) (2008). NIAUR (2010) provides figures for household electricity use. However, estimates of electricity use in other sectors are not available. Instead, we allocate electricity use in these sectors using the appropriate United Kingdom (UK) and ROI shares. Thus, we have two estimates for the value of lost load in these sectors. GVA per sector data is taken from the Office for National Statistics (ONS) (2009) and we convert these to constant prices using a deflator specified by HM Treasury (2010). Operating hours in the industrial and service sectors are taken from de Nooij et al. (2007). Estimates of the number of hours worked and average earnings are from the Annual Survey of Hours and Earnings (ASHE) 1999-2008 (ONS, 2010a). UK tax rates are taken from the Organisation for Economic Co-operation and Development (OECD) (2009) while estimates of the number employed are taken from the Department of Enterprise, Trade and Investment (DETI) (2010). Wages are adjusted for inflation using the Consumer Price Index for the UK (ONS, 2010b). The population of NI is estimated by the Northern Ireland Statistics and Research Agency (NISRA) (2008).

With regard to ROI, ESB International (ESBI) (2009) has provided data on the electricity profiles of the residential, industrial and commercial sectors for each hour of 2001. Data on annual electricity use per sector are taken from the Sustainable Energy Authority of Ireland (SEAI) (2009).

Estimates of GVA per sector in constant prices are taken from the Central Statistics Office of Ireland (CSO) (2010). Population and labour force data are taken from the Groningen Growth and Development Centre (GGDC) (2010). Data on after tax non agricultural wages in constant prices[4] are taken from the Economic and Social Research Institute (ESRI) databank (Bergin and FitzGerald, 2009). In 2004 the average hourly non agricultural wage after tax was €29. In 2009 it was €33.16. As mentioned previously, we also incorporate the 2005 Time Use in Ireland Survey (ESRI, 2005) in order to estimate the value of lost load in the residential sector.

4. Results

Figure 1 shows the value of lost load in NI if power outages had occurred in 2007. The value of electricity to the industrial and commercial sectors varies depending on whether electricity use was allocated using ROI or NI shares. The use of ROI and UK shares result is a surprisingly similar value of lost load in the industrial sector. The value of lost load in the commercial sector varies depending on whether UK or ROI shares are used. This can be attributed to the higher share of electricity use in the UK services sector relative to that of ROI. The value of lost load in the residential sector far outweighs that of the other sectors.

[4] 2004=100

Figure 1. The Value of Lost Load in NI 2007

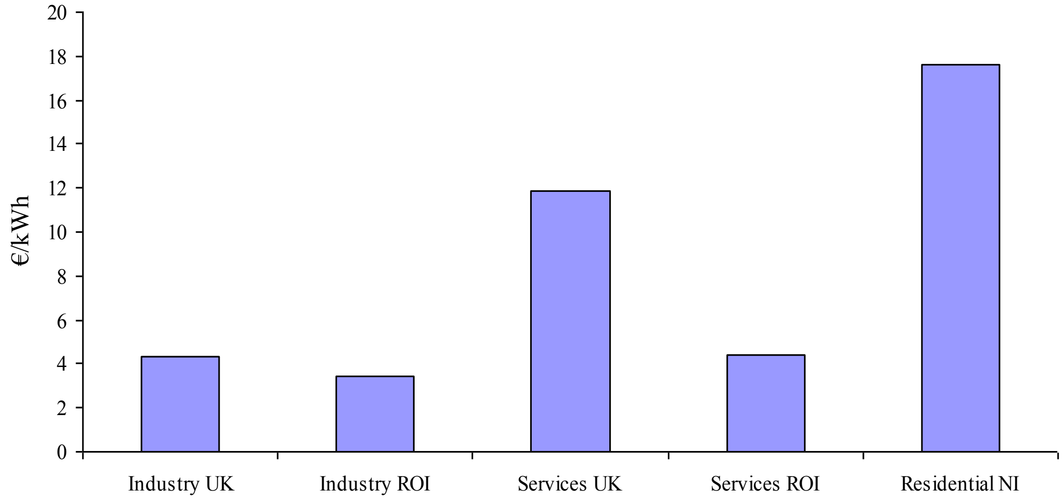
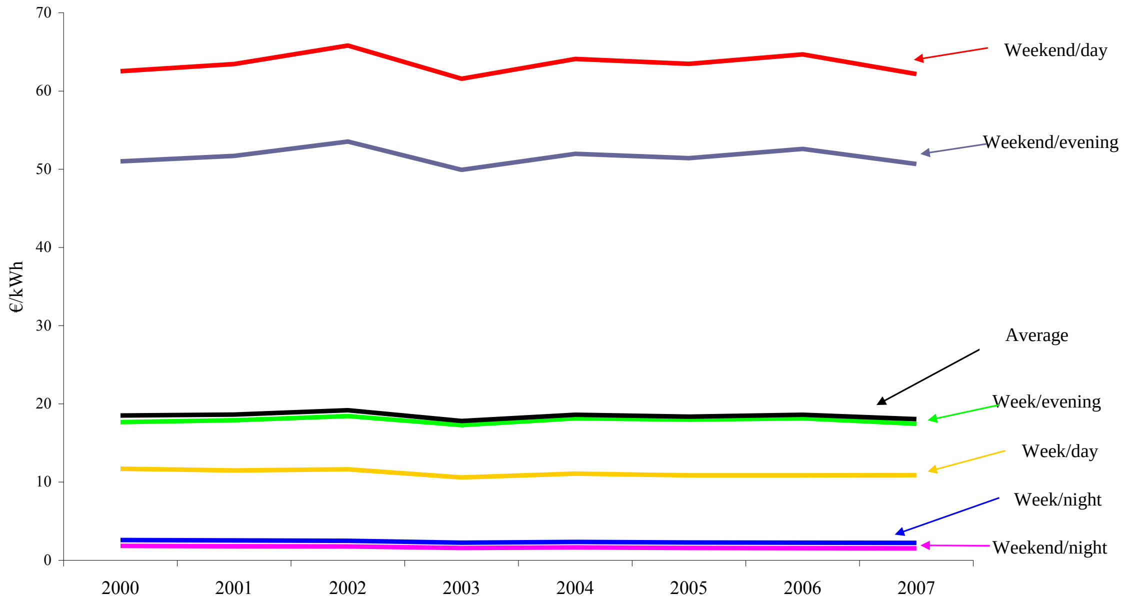


Figure 2 shows the value of lost load in NI by time of day over the period 2000 to 2007.[5] The value differs substantially between midweek and weekend days and by time of day. The value of lost electricity to industry is highest on midweek days between the hours of 8.00AM and 6.00PM. For households, the value of electricity is highest at the weekends, especially during the day. Because the value of lost load is so much greater to households than it is to industry, we see that this pattern is repeated in the average results. As expected, the loss is lowest during the night both midweek and at the weekend.

[5] We estimated these values using both ROI and NI electricity shares in the non residential sector and found that the results were very similar. This graph represents an average of the two results.

Figure 2. NI value of lost load by time of week and year (2000-2007)



With regard to ROI, the average value of lost load is highest in the residential sector. This happens because of the relatively high value which is placed on time spent at non paid work on both midweek and weekend days and evenings. The total value of hourly electricity is also much higher in the residential sector than it is in the industrial and commercial sectors. The total cost of a lost hour of electricity varies considerably by time of day, especially in the commercial and residential sectors.

Figure 3 shows the average value in 2008 of a lost hour to the industrial sector at different times of year. Note that figure 3 shows the value per hour rather than the value per kWh. The bars and lines represent midweek and weekend days respectively. The pattern is somewhat similar across seasons. The value of a lost hour is lowest between the hours of 4.00PM and 6.00PM in winter. This may be partly due to a lower demand for cooling at this time of year. The value of a lost hour is highest at 7.00AM on midweek days all year round. At weekends, however, the value of a lost hour falls between 6.00AM and 8.00AM and between 3.00PM and 6.00PM. This pattern is repeated throughout the year. In general, the value of a lost hour is lower at weekends than it is midweek due to reduced activity on Saturdays and Sundays.

Figure 3. ROI Industry hourly value of electricity by season and time of week (2008)

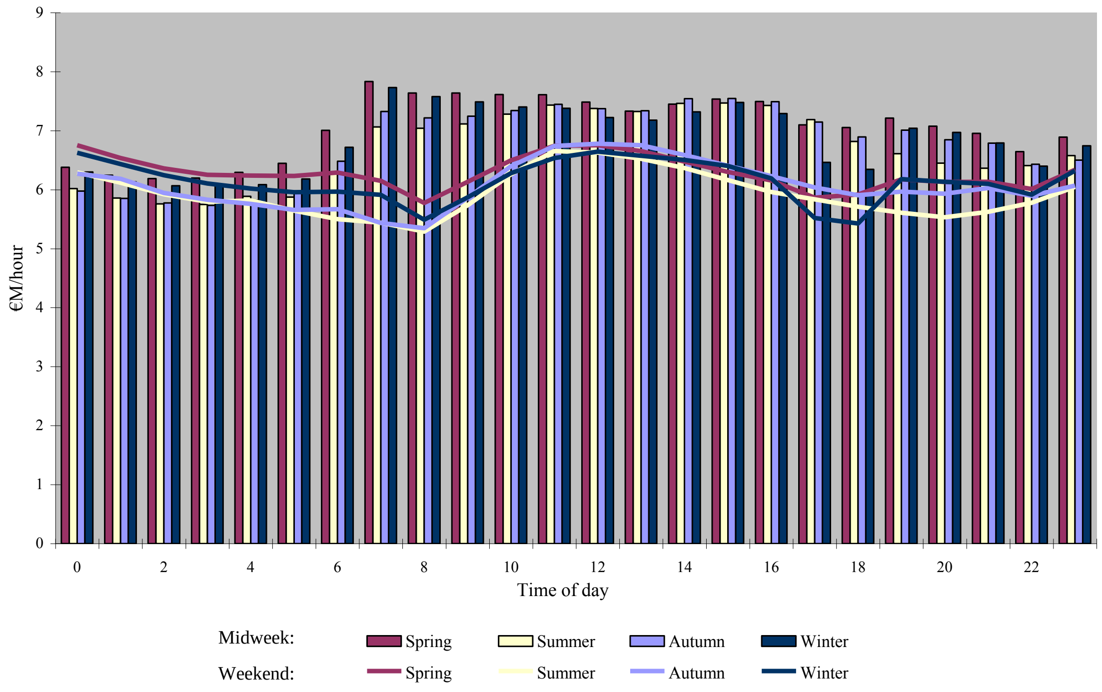


Figure 4 shows the average value in 2008 of a lost hour of electricity in the commercial sector at different times of year for midweek (represented by bars) and weekend (represented by lines) days. Again, figure 4 shows the value of electricity per hour rather than per kWh. Both midweek and weekend days follow a similar pattern. As expected, in each case, the loss is highest during standard business hours. The value can be as high as €17 million per hour. As the commercial sector represents all of the service industry and the public service, it is not surprising that the loss is lowest in summer when the demand for electricity is also low because of natural light.

Figure 4. ROI Commercial hourly value of electricity by season and time of week (2008)

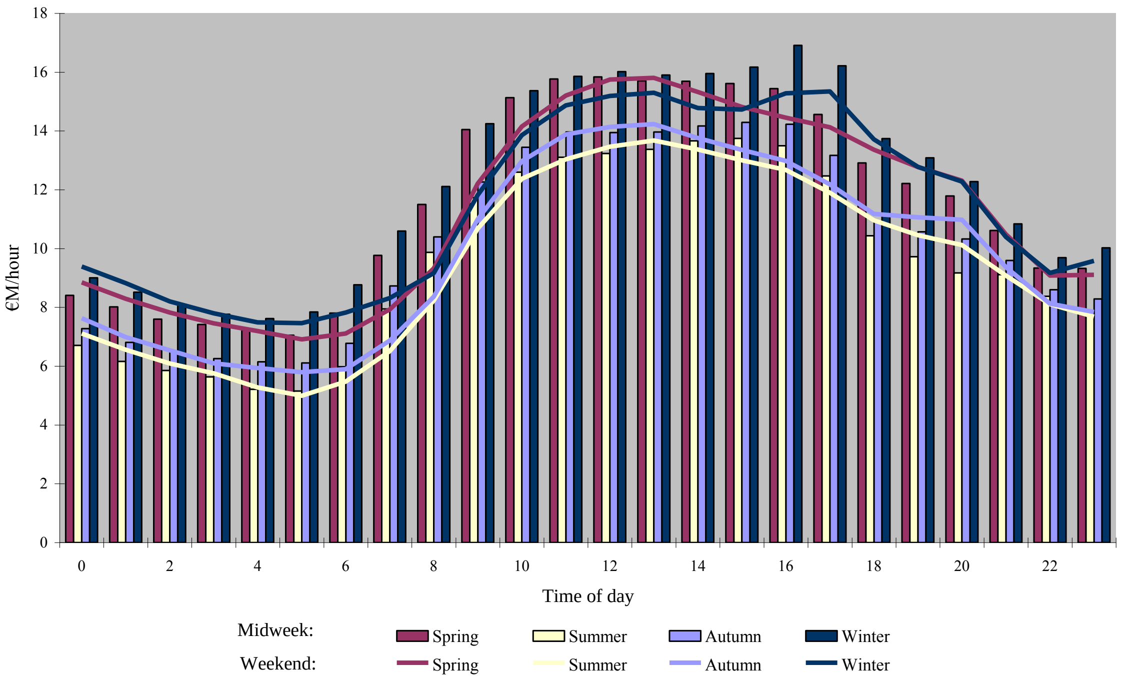


Figure 5 shows the value of a lost unit of electricity in households in 2008. Unlike figures 3 and 4, figure 5 shows the value of lost load. The bars, which represent midweek days, show that the value of lost load is low during the night and increases substantially between the hours of 5.00AM and 7.00AM. It then remains relatively steady until evening time, mainly driven by the fact that the value of time spent on non paid work is low and stable between 8.00-9.00AM and 5.00-6.00PM when most people are at work. On midweek days, in the evening time, the value is highest in summer and lowest in winter. Although electricity use is highest in winter, electricity is valued in terms of time spent on non paid work and thus the amount people are willing to pay per unit of electricity falls.[6] However, the hourly value of electricity will remain high in winter. The continuous lines represent the value of lost load at weekends. Again, the value is lowest during the night and increases between the hours of 5.00AM and 8.00AM. From midday onwards, the value varies by season. At 8.00PM on weekend evenings in summer, the value of lost load reaches an average of €51/kWh when most people are at home but not

[6] Because the value of lost load is defined as loss of time spent on non paid work divided by electricity use, the overall value people are willing to pay for a lost unit of electricity will fall when electricity use, the denominator, increases.

asleep. For the most part, the value of lost load on weekend days exceeds that of midweek days.

Figure 5. Household value of lost load by season and time of week in ROI (2008)

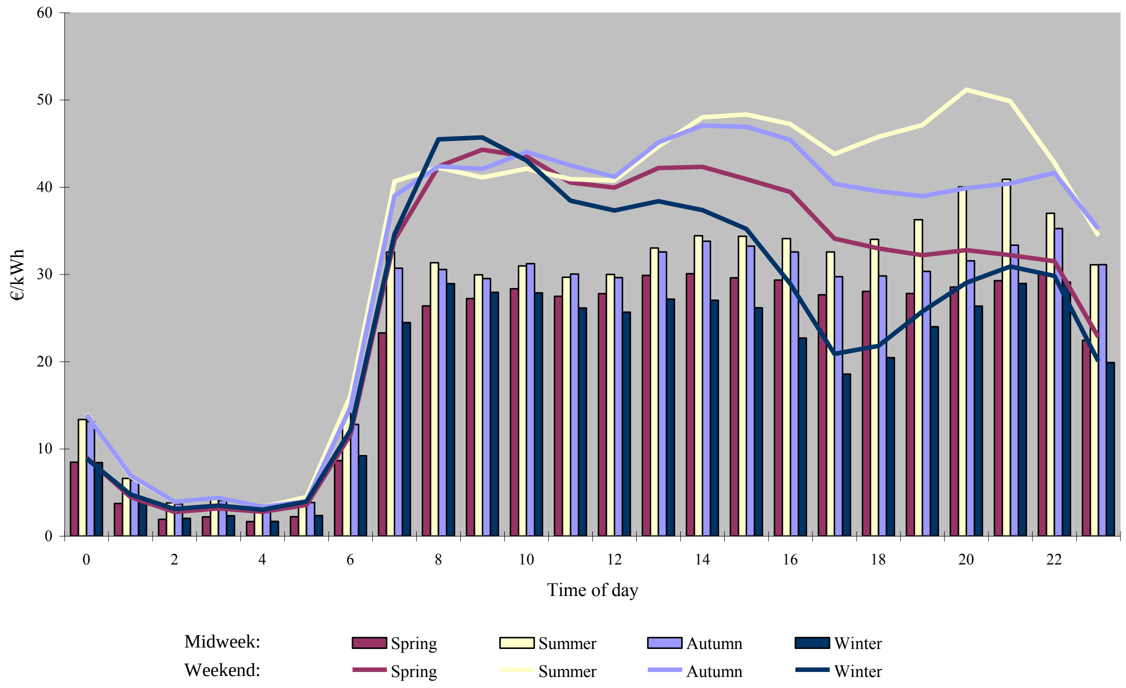
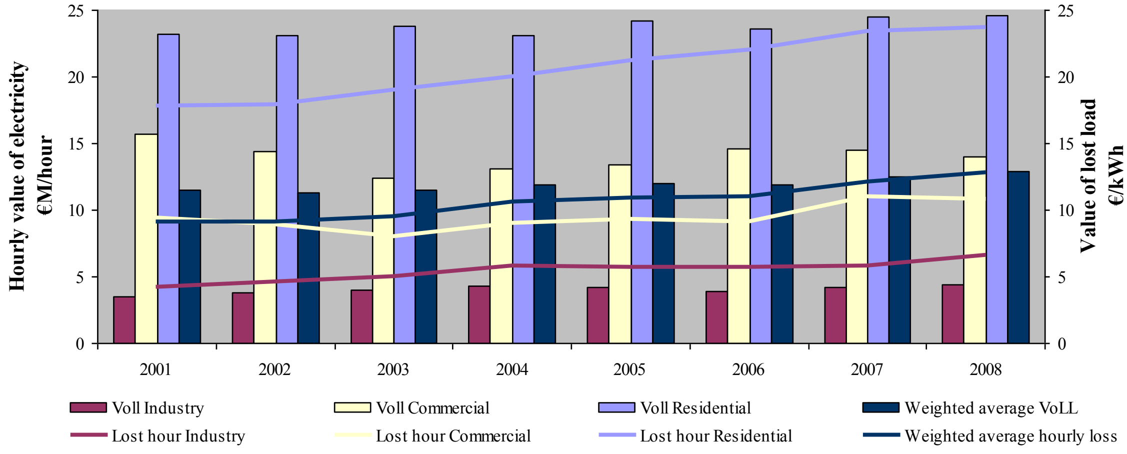


Figure 6 shows the evolution of the value of electricity over time for both the hourly value (€/hr) and the value of lost load (€/kWh). The total value of a lost hour of electricity to all three sectors (indicated by the lines on the chart) increased between 2001 and 2008. We estimate the cumulative annual growth rates in the value of a lost hour of electricity in the industrial, commercial and residential sectors as being 6.7%, 1.9% and 4.2% respectively. The bars (and secondary axis) on the chart show the average value of losing 1 kWh of electricity in each of the sectors. The residential values increased only slightly over the period (by 0.8%). This trend is largely due to the stabilisation of wage taxes and saturation of the employment ratio. The industrial value of lost load increased over the period as GVA outgrew electricity use in this sector, however, the commercial value decreased slightly.

Figure 6. Hourly value of electricity and value of lost load in ROI 2001-2008



5. Discussion

5.1. Current capacity regulations

On 1st November 2007 the trading of wholesale electricity in ROI and NI began on an all-island basis. In this Single Electricity Market (SEM) all electricity generated in or imported into Ireland must be sold into a common pool and all electricity for consumption in Ireland or export to other countries must be purchased from the pool. The SEM replaces the old system in which a central planner would specify a level of capacity (for example, by estimating expected demand plus a reserve margin) thought sufficient to meet a defined standard for system reliability. The aim of the SEM is to allow market forces to ensure that adequate capacity is built in an efficient and timely manner. It is hoped that this will lower prices in the long run.

The market operates on pool arrangements whereby all suppliers pay and generators receive the same System Marginal Price.[7] Generators also receive capacity payments, which are based on annually determined fixed amounts and are ultimately paid for by consumers. The aim of such payments is to increase certainty of revenues, encourage investment and ensure that capacity is made available when it is required. The benefit for generators is that if they make plant available when capacity margins are tight, revenues

[7] The system marginal price is determined by the bid price of the marginal dispatched plant and all dispatched plants receive this price. Dispatched plants are chosen on the basis that all plants are stacked according to their bid, from the cheapest to the most expensive. The cheapest plants that are needed to match demand in each half hour are dispatched.

can be earned which are greater than the short run costs. The level of payments is based on estimates of the tightness of the market and the cost of new peaking capacity. Since this system has been implemented availability of plants has increased slightly in ROI.

Current dispatchable capacity stands at approximately 7,000 MW. Eirgrid (2009) estimates that at times of high demand, surplus capacity is currently about 800 MW. However, Malaguzzi Valeri and Tol (2006) have suggested that forced outages among a small number of ageing generation units could sharply increase the risk of shortages if they were to coincide with peak winter demand. Continued increases in demand (although the recession resulted in decreased demand last year) and planned retirement of old plant have increased the need for investment in new plants over the coming years. According to the energy forecasts of SEAI (Walker et al., 2009), electricity demand is set to increase by 12% between 2008 and 2020.[8] The growing importance of wind generation in the SEM suggests that the system will need more mid-merit and peaking capacity to help meet system reliability goals in future. Peaking plants can be switched on and off relatively easily due to the relatively high level of variable costs to fixed costs that they face. Thus, these plants can be used to meet fluctuating demand. Base load plants, on the other hand, face relatively high fixed costs to variable costs and so, it is most efficient to use them in a continuous way. Mid-merit plants generally produce electricity for several hours at a time but can be shut down and restarted on a daily basis.

5.2. The implications of using the estimated value of lost load

The value placed on lost load should be used to assist decisions regarding investment in new capacity and closure of older, less efficient plants in order to meet the desired supply security. Capacity management is increasingly important as electricity supply and demand become more variable. In Ireland, the growing share of wind power in total generation means that supply is already less predictable than it used to be. The expected growth in interconnection, electric and hybrid vehicles, and smart appliances will further complicate capacity management.

Our results show that the weighted average value of lost load in ROI is €12.9/kWh. This indicates that the €10/kWh set by CER & NIAUR is too low for short term loss of load

[8] Despite forecasted decreases in demand between 2008 and 2012, the average annual growth rate for both electricity and total energy is estimated to be 0.9% between 2008 and 2020.

(several hours). The average value of lost load in NI in 2007 was €4/kWh for the industrial sector, €13/kWh for the commercial sector and €18/kWh for the residential sector. In contrast, in ROI in 2008, the average value of lost load was around €4/kWh for the industrial sector, €14/kWh for the commercial sector and €24.6/kWh for households. The residential value is an average, brought down by the very low values which occur during the night. It can reach values over €60/kWh, usually at weekends when most people are at home. Between the hours of 6.00PM and 9.00PM on midweek days, when brown-outs are most likely, hourly values of electricity are at their highest; between €41 million and €45 million. In 2008, peak electricity demand occurred at 5.00PM on 15th December. At this time, the average value of lost load was €15.2/kWh but it was even higher at €35/kWh between 8.00AM and 9.00AM that day. Thus, the peak value of lost load and peak electricity demand do not occur simultaneously. This opens some opportunities for peak shifting to minimise the damage of brown-outs.

The estimate for NI suffers from a lack of detailed data on residential electricity use and time use. The average VoLL we have estimated for NI may be an overestimate, as the incorporation of detailed data on residential electricity use for ROI has resulted in a downward revision of the weighted average value of lost load compared to that estimated by Tol (2007).

At present, during a brown-out, it is policy to shut off electricity in residential areas first, and in industrial estates later. As the value of lost load is highest in the residential sector, in both NI and ROI (during the relevant hours), this policy may be reconsidered. However, the decision as to which sector will be subject to rationing should depend on the day and time at which the shortage occurs. During the hours of 1.00AM and 6.00AM the value of a lost hour of electricity in the industrial and commercial sectors is much higher than it is in the residential sector.

6. Conclusion

In this paper, we use a simple version of the production function approach to estimate the short term value of lost load in NI for the period 2000-2007 and in ROI for the period 2001-2008. We find that:

- VoLL differs by sector and is highest in the residential sector in both ROI and NI
- VoLL differs substantially by time of day and week

- More detailed data for ROI enables us to show that VoLL also differs by time of year
- The value of a lost hour of electricity is driven by electricity demand in that hour
- The peak VoLL and peak electricity demand do not occur simultaneously
- VoLL in ROI has increased between 2001 and 2008 and is currently higher than the Regulator assumes it to be

These results come with a number of caveats. More detailed data on electricity use per type of user in NI would enable us to deliver more accurate results. It would be good to test the validity of our results based on the production function approach with estimates based on contingent valuation and contingent choice methods as well as with estimates based on observed black-outs. Our estimates are valid only for short interruptions of the power supply. Longer interruptions, while much more unlikely, may well be disproportionally damaging. All this is deferred to future research.

Acknowledgements

Sean Lyons, Laura Malaguzzi Valeri, Pat McCullen and Gerry White had excellent comments on an earlier version of this paper. Financial support by ESBI is gratefully acknowledged. All errors and opinions are ours.

References

Bazilian, M., O'Leary, F., O'Gallachoir, B., Howley, M., 2006. Security of Supply in Ireland. Sustainable Energy Ireland, Cork.

Beenstock, M., Goldin, E., Haitovsky, Y., 1998. Response Bias in a Conjoint Analysis of Power Outages. Energy Economics, 20, (1998) pp. 135-156.

Bergin, A., FitzGerald, J., 2009. The ESRI Data Bank. Economic and Social Research Institute, Dublin.

CER and NIAUR, 2007. The Value of Lost Load, the Market Price Cap and the Market Price Floor -- A Response and Decision Paper. Commission for Electricity Regulation and Northern Ireland Authority for Utility Regulation, Dublin.

CER and NIAUR, 2009. The Value of Lost Load in 2010 Decision Paper.

Commission for Electricity Regulation and Northern Ireland Authority for Utility Regulation, Dublin.

Corwin, J., Miles, W., 1978. Impact Assessment of the 1977 New York City Blackout. US Department of Energy, Washington, DC.

CSO, 2010. National Accounts. Central Statistics Office (http://www.cso.ie/statistics/nationalacc.htm) (accessed 11 June 2010)

de Nooij, M., Koopmans, C., Bijvoet, C., 2007. The value of supply security: The costs of power interruptions: Economic input for damage reduction and investment in networks. Energy Economics, 29, (2007) pp. 277-295.

DECC, 2008. Sub National Electricity Figures. Department of Energy and Climate Change (http://www.decc.gov.uk/en/content/cms/statistics/publications/ecuk/ecuk.aspx) (accessed 14 June 2010)

DETI, 2010. Employment Statistics. Department of Enterprise, Trade and Investment (http://www.detini.gov.uk/deti-stats-index/stats-labour-market/stats-labour-market-employment.htm) (accessed 14 June 2010)

Eirgrid, 2009. Generation Adequacy Report 2010-2016. Eirgrid (http://www.eirgrid.com/media/Generation%20Adequacy%20Report%202010-2016.pdf) (accessed 11 June 2010)

Elexon, 2007. Load Profiles and their Use in Electricity Settlement. Elexon (http://www.elexon.co.uk/documents/Participating_in_the_Market/Market_Guidance_-_Industry_Helpdesk_faqs/Load_Profiles.pdf) (accessed 28 May 2010)

ESBI, 2009. Electricity Profiles 2001. ESB International, Dublin.

ESRI, 2005. Irish National Time Use Survey 2005. Economic and Social Research Institute, Dublin.

GGDC, 2010. Total Economy Database. Groningen Growth and Development Centre (http://www.ggdc.net) (accessed 14 June 2010)

HM Treasury, 2010. GDP Deflators. Her Majesty's Treasury (http://www.hm-treasury.gov.uk/d/gdp_deflators.xls) (accessed 04 June 2010)

Lyons, S., Fitz Gerald, J., McCarthy, D., Malaguzzi Valeri, L., Tol, R.S.J., 2007. Preserving Electricity Market Efficiency while Closing Ireland's Capacity Gap. Quarterly Economic Commentary, Autumn, 62-82 (2007).

Malaguzzi Valeri, L., Tol, R.S.J., 2006. Electricity Shortages in Ireland: Probability and Consequences. Quarterly Economic Review, Winter, (2006) pp. 1-7.

NIAUR, 2010. Electricity. The Northern Ireland Authority for Utility Regulation (http://www.niaur.gov.uk/electricity) (accessed 21 May 2010)

NISRA, 2008. Demography. Northern Ireland Statistics and Research Agency (http://www.nisra.gov.uk/archive/demography/population/midyear/NI_Home_Pop_5yrbds(1961-2008).xls) (accessed 21 May 2010)

OECD, 2009. Taxing Wages 2008. Organisation for Economic Co-operation and Development, Paris.

ONS, 2009. NUTS1 GVA (1989-2008) Data. Office for National Statistics (http://www.statistics.gov.uk/downloads/theme_economy/CRC2008ALL.pdf) (accessed 24 May 2010)

ONS, 2010a. ASHE Results. Office for National Statistics (http://www.statistics.gov.uk/statBase/product.asp?vlnk=13101) (accessed 24 May 2010)

ONS, 2010b. Consumer Price Indices. Office for National Statistics (http://www.statistics.gov.uk/statbase/Product.asp?vlnk=868) (accessed 24 May 2010)

SEAI, 2009. Energy Balance Statistics, Sustainable Energy Authority of Ireland (http://www.cso.ie/px/sei/database/SEI/Energy%20Balance%20Statistics/Energy%20Balance%20Statistics.asp) (accessed 21 May 2010)

Tol, R.S.J., 2007. The Value of Lost Load, in: O'Leary, F., Bazilian, M., Howley, M., O'Gallachoir, B. (Eds.), Security of Supply in Ireland 2007 Report, Sustainable Energy Ireland, Cork, (2007) pp. 63-66.

Walker, N., Scheer, J., Clancy, M., Ó Gallachóir,B., 2009. Energy Forecasts for Ireland to 2020. Sustainable Energy Ireland, Cork.

Appendix

A1. Sample Data for ROI: 1st January 2008

Hour	Industrial demand (gWh)	Industrial VoLL (€)	Cost of 1 hour shortage: Industry (€)	Commercial demand (gWh)	Commercial VoLL (€)	Cost of 1 hour shortage: Commercial (€)	Residential demand (gWh)	Residential VoLL (€)	Cost of 1 hour shortage: Residential (€)
0	1150	4.37	5.03	671	14	9.42	1316	6.19	8.14
1	1140	4.37	4.98	669	14	9.40	1062	2.53	2.69
2	1104	4.37	4.83	610	14	8.57	902	1.06	0.95
3	1094	4.37	4.78	567	14	7.95	766	1.29	0.99
4	1063	4.37	4.65	544	14	7.64	674	0.80	0.54
5	1057	4.37	4.62	541	14	7.59	613	1.37	0.84
6	1082	4.37	4.73	575	14	8.08	568	8.51	4.83
7	1102	4.37	4.82	628	14	8.81	513	34.98	17.94
8	976	4.37	4.26	675	14	9.47	512	52.22	26.73
9	955	4.37	4.18	781	14	10.96	546	46.80	25.55
10	983	4.37	4.30	903	14	12.68	659	38.37	25.30
11	1082	4.37	4.73	979	14	13.74	770	31.10	23.95
12	1166	4.37	5.10	1038	14	14.57	879	28.67	25.20
13	1176	4.37	5.14	1074	14	15.07	941	26.72	25.14
14	1204	4.37	5.27	1058	14	14.85	885	27.97	24.76
15	1202	4.37	5.26	1063	14	14.92	872	29.18	25.44
16	1189	4.37	5.20	1083	14	15.20	1092	25.74	28.11
17	1049	4.37	4.58	1042	14	14.62	1569	21.71	34.06
18	1069	4.37	4.67	875	14	12.29	1714	24.32	41.69
19	1294	4.37	5.65	814	14	11.43	1441	29.86	43.03
20	1316	4.37	5.75	754	14	10.59	1375	32.21	44.29
21	1277	4.37	5.58	686	14	9.62	1336	34.18	45.67
22	1217	4.37	5.32	608	14	8.53	1294	32.37	41.87
23	1286	4.37	5.62	625	14	8.77	1230	19.84	24.39

A2. Sample data for Northern Ireland: 2007

Northern Ireland 2007	**Industrial and Commercial demand (gWh)** *	**Industrial and Commerical Voll (€)***	**Residential demand (gW)**	**Residential Voll (€)**	**Average VoLL Northern Ireland (€)**
Annual electricity demand	5118		3412		18
Distribution of electricity demand					
Midweek day	3490	10	1082	13	11
Midweek evening	521	4	864	26	17
Midweek night	695	4	491	0	2
Weekend day	176	4	433	85	62
Weekend evening	101	4	346	64	51
Weekend night	134	4	196	0	2

*The Industrial and Commercial figures were estimated twice, once with UK shares and once with ROI shares as exact data for NI do not exist. The figures shown here represent an average of the two results.

Year	Number	Title/Author(s) ESRI Authors/Co-authors *Italicised*
2010		
	356	Public Policy Towards the Sale of State Assets in Troubled Times: Lessons from the Irish Experience *Paul K. Gorecki, Sean Lyons* and *Richard S. J. Tol*
	355	The Impact of Ireland's Recession on the Labour Market Outcomes of its Immigrants *Alan Barrett* and *Elish Kelly*
	354	Research and Policy Making *Frances Ruane*
	353	Market Regulation and Competition; Law in Conflict: A View from Ireland, Implications of the Panda Judgment Philip Andrews and *Paul K Gorecki*
	352	Designing a property tax without property values: Analysis in the case of Ireland *Karen Mayor, Seán Lyons* and *Richard S.J. Tol*
	351	Civil War, Climate Change and Development: A Scenario Study for Sub-Saharan Africa *Conor Devitt* and *Richard S.J. Tol*
	350	Regulating Knowledge Monopolies: The Case of the IPCC *Richard S.J. Tol*
	349	The Impact of Tax Reform on New Car Purchases in Ireland *Hugh Hennessy* and *Richard S.J. Tol*
	348	Climate Policy under Fat-Tailed Risk: An Application of FUND *David Anthoff* and *Richard S.J. Tol*
	347	Corporate Expenditure on Environmental Protection *Stefanie A. Haller* and *Liam Murphy*
	346	Female Labour Supply and Divorce: New Evidence from Ireland Olivier Bargain, Libertad González, *Claire Keane* and Berkay Özcan
	345	A Statistical Profiling Model of Long-Term Unemployment Risk in Ireland *Philip J. O'Connell, Seamus McGuinness, Elish Kelly*
	344	The Economic Crisis, Public Sector Pay, and the Income Distribution

		Tim Callan, Brian Nolan (UCD) and *John Walsh*
	343	Estimating the Impact of Access Conditions on Service Quality in Post *Gregory Swinand, Conor O'Toole* and *Seán Lyons*
	342	The Impact of Climate Policy on Private Car Ownership in Ireland *Hugh Hennessy* and *Richard S.J. Tol*
	341	National Determinants of Vegetarianism *Eimear Leahy, Seán Lyons* and *Richard S.J. Tol*
	340	An Estimate of the Number of Vegetarians in the World *Eimear Leahy, Seán Lyons* and *Richard S.J. Tol*
	339	International Migration in Ireland, 2009 *Philip J O'Connell* and *Corona Joyce*
	338	The Euro Through the Looking-Glass: Perceived Inflation Following the 2002 Currency Changeover *Pete Lunn* and *David Duffy*
	337	Returning to the Question of a Wage Premium for Returning Migrants *Alan Barrett and Jean Goggin*
2009	336	What Determines the Location Choice of Multinational Firms in the ICT Sector? *Iulia Siedschlag, Xiaoheng Zhang, Donal Smith*
	335	Cost-benefit analysis of the introduction of weight-based charges for domestic waste – West Cork's experience *Sue Scott* and *Dorothy Watson*
	334	The Likely Economic Impact of Increasing Investment in Wind on the Island of Ireland *Conor Devitt, Seán Diffney, John Fitz Gerald, Seán Lyons* and *Laura Malaguzzi Valeri*
	333	Estimating Historical Landfill Quantities to Predict Methane Emissions *Seán Lyons,* Liam Murphy and *Richard S.J. Tol*
	332	International Climate Policy and Regional Welfare Weights Daiju Narita*, Richard S. J. Tol,* and *David Anthoff*
	331	A Hedonic Analysis of the Value of Parks and Green Spaces in the Dublin Area *Karen Mayor, Seán Lyons, David Duffy* and *Richard S.J. Tol*

330	Measuring International Technology Spillovers and Progress Towards the European Research Area *Iulia Siedschlag*
329	Climate Policy and Corporate Behaviour *Nicola Commins,* Se*án Lyons,* Marc Schiffbauer, and *Richard S.J. Tol*
328	The Association Between Income Inequality and Mental Health: Social Cohesion or Social Infrastructure *Richard Layte* and *Bertrand Maître*
327	A Computational Theory of Exchange: Willingness to pay, willingness to accept and the endowment effect *Pete Lunn* and Mary Lunn
326	Fiscal Policy for Recovery *John Fitz Gerald*
325	The EU 20/20/2020 Targets: An Overview of the EMF22 Assessment Christoph Böhringer, Thomas F. Rutherford, and *Richard S.J. Tol*
324	Counting Only the Hits? The Risk of Underestimating the Costs of Stringent Climate Policy Massimo Tavoni, *Richard S.J. Tol*
323	International Cooperation on Climate Change Adaptation from an Economic Perspective Kelly C. de Bruin, Rob B. Dellink and *Richard S.J. Tol*
322	What Role for Property Taxes in Ireland? *T. Callan, C. Keane* and *J.R. Walsh*
321	The Public-Private Sector Pay Gap in Ireland: What Lies Beneath? *Elish Kelly, Seamus McGuinness, Philip O'Connell*
320	A Code of Practice for Grocery Goods Undertakings and An Ombudsman: How to Do a Lot of Harm by Trying to Do a Little Good *Paul K Gorecki*
319	Negative Equity in the Irish Housing Market *David Duffy*
318	Estimating the Impact of Immigration on Wages in Ireland *Alan Barrett, Adele Bergin* and *Elish Kelly*
317	Assessing the Impact of Wage Bargaining and Worker

Preferences on the Gender Pay Gap in Ireland Using the National Employment Survey 2003
Seamus McGuinness, Elish Kelly, Philip O'Connell, Tim Callan

316 Mismatch in the Graduate Labour Market Among Immigrants and Second-Generation Ethnic Minority Groups
Delma Byrne and *Seamus McGuinness*

315 Managing Housing Bubbles in Regional Economies under EMU: Ireland and Spain
Thomas Conefrey and *John Fitz Gerald*

314 Job Mismatches and Labour Market Outcomes
Kostas Mavromaras*, Seamus McGuinness,* Nigel O'Leary, Peter Sloane and Yin King Fok

313 Immigrants and Employer-provided Training
Alan Barrett, Séamus McGuinness, Martin O'Brien and *Philip O'Connell*

312 Did the Celtic Tiger Decrease Socio-Economic Differentials in Perinatal Mortality in Ireland?
Richard Layte and *Barbara Clyne*

311 Exploring International Differences in Rates of Return to Education: Evidence from EU SILC
Maria A. Davia, *Seamus McGuinness* and *Philip, J. O'Connell*

310 Car Ownership and Mode of Transport to Work in Ireland
Nicola Commins and *Anne Nolan*

309 Recent Trends in the Caesarean Section Rate in Ireland 1999-2006
Aoife Brick and *Richard Layte*

308 Price Inflation and Income Distribution
Anne Jennings, Seán Lyons and *Richard S.J. Tol*

307 Overskilling Dynamics and Education Pathways
Kostas Mavromaras, *Seamus McGuinness*, Yin King Fok

306 What Determines the Attractiveness of the European Union to the Location of R&D Multinational Firms?
Iulia Siedschlag, Donal Smith, Camelia Turcu, Xiaoheng Zhang

305 Do Foreign Mergers and Acquisitions Boost Firm Productivity?
Marc Schiffbauer, Iulia Siedschlag, Frances Ruane

304 Inclusion or Diversion in Higher Education in the Republic of Ireland?
Delma Byrne

303 Welfare Regime and Social Class Variation in Poverty and Economic Vulnerability in Europe: An Analysis of EU-SILC
Christopher T. Whelan and *Bertrand Maître*

302 Understanding the Socio-Economic Distribution and Consequences of Patterns of Multiple Deprivation: An Application of Self-Organising Maps
Christopher T. Whelan, Mario Lucchini, Maurizio Pisati and *Bertrand Maître*

301 Estimating the Impact of Metro North
Edgar Morgenroth

300 Explaining Structural Change in Cardiovascular Mortality in Ireland 1995-2005: A Time Series Analysis
Richard Layte, Sinead O'Hara and Kathleen Bennett

299 EU Climate Change Policy 2013-2020: Using the Clean Development Mechanism More Effectively
Paul K Gorecki, Seán Lyons and *Richard S.J. Tol*

298 Irish Public Capital Spending in a Recession
Edgar Morgenroth

297 Exporting and Ownership Contributions to Irish Manufacturing Productivity Growth
Anne Marie Gleeson, *Frances Ruane*

296 Eligibility for Free Primary Care and Avoidable Hospitalisations in Ireland
Anne Nolan

295 Managing Household Waste in Ireland: Behavioural Parameters and Policy Options
John Curtis, Seán Lyons and *Abigail O'Callaghan-Platt*

294 Labour Market Mismatch Among UK Graduates; An Analysis Using REFLEX Data
Seamus McGuinness and *Peter J. Sloane*

293 Towards Regional Environmental Accounts for Ireland
Richard S.J. Tol , Nicola Commins, Niamh Crilly, Sean Lyons and *Edgar Morgenroth*

292 EU Climate Change Policy 2013-2020: Thoughts on Property Rights and Market Choices
Paul K. Gorecki, Sean Lyons and *Richard S.J. Tol*

291	Measuring House Price Change *David Duffy*
290	Intra-and Extra-Union Flexibility in Meeting the European Union's Emission Reduction Targets *Richard S.J. Tol*
289	The Determinants and Effects of Training at Work: Bringing the Workplace Back In *Philip J. O'Connell* and *Delma Byrne*
288	Climate Feedbacks on the Terrestrial Biosphere and the Economics of Climate Policy: An Application of *FUND* *Richard S.J. Tol*
287	The Behaviour of the Irish Economy: Insights from the HERMES macro-economic model *Adele Bergin, Thomas Conefrey, John FitzGerald* and *Ide Kearney*
286	Mapping Patterns of Multiple Deprivation Using Self-Organising Maps: An Application to EU-SILC Data for Ireland Maurizio Pisati, *Christopher T. Whelan*, Mario Lucchini and *Bertrand Maître*
285	The Feasibility of Low Concentration Targets: An Application of FUND *Richard S.J. Tol*
284	Policy Options to Reduce Ireland's GHG Emissions Instrument choice: the pros and cons of alternative policy instruments Thomas Legge and *Sue Scott*
283	Accounting for Taste: An Examination of Socioeconomic Gradients in Attendance at Arts Events *Pete Lunn* and *Elish Kelly*
282	The Economic Impact of Ocean Acidification on Coral Reefs Luke M. Brander, Katrin Rehdanz, *Richard S.J. Tol*, and Pieter J.H. van Beukering
281	Assessing the impact of biodiversity on tourism flows: A model for tourist behaviour and its policy implications Giulia Macagno, Maria Loureiro, Paulo A.L.D. Nunes and *Richard S.J. Tol*
280	Advertising to boost energy efficiency: the Power of One campaign and natural gas consumption *Seán Diffney, Seán Lyons* and *Laura Malaguzzi Valeri*

279 International Transmission of Business Cycles Between Ireland and its Trading Partners
Jean Goggin and *Iulia Siedschlag*

278 Optimal Global Dynamic Carbon Taxation
David Anthoff

277 Energy Use and Appliance Ownership in Ireland
Eimear Leahy and *Seán Lyons*

276 Discounting for Climate Change
David Anthoff, Richard S.J. Tol and Gary W. Yohe

275 Projecting the Future Numbers of Migrant Workers in the Health and Social Care Sectors in Ireland
Alan Barrett and Anna Rust

274 Economic Costs of Extratropical Storms under Climate Change: An application of FUND
Daiju Narita*, Richard S.J. Tol, David Anthoff*

273 The Macro-Economic Impact of Changing the Rate of Corporation Tax
Thomas Conefrey and *John D. Fitz Gerald*

272 The Games We Used to Play
An Application of Survival Analysis to the Sporting Life-course
Pete Lunn

2008

271 Exploring the Economic Geography of Ireland
Edgar Morgenroth

270 Benchmarking, Social Partnership and Higher Remuneration: Wage Settling Institutions and the Public-Private Sector Wage Gap in Ireland
Elish Kelly, Seamus McGuinness, Philip O'Connell

269 A Dynamic Analysis of Household Car Ownership in Ireland
Anne Nolan

268 The Determinants of Mode of Transport to Work in the Greater Dublin Area
Nicola Commins and *Anne Nolan*

267 Resonances from *Economic Development* for Current Economic Policymaking
Frances Ruane

266 The Impact of Wage Bargaining Regime on Firm-Level

	Competitiveness and Wage Inequality: The Case of Ireland *Seamus McGuinness, Elish Kelly* and *Philip O'Connell*
265	Poverty in Ireland in Comparative European Perspective *Christopher T. Whelan* and *Bertrand Maître*
264	A Hedonic Analysis of the Value of Rail Transport in the Greater Dublin Area *Karen Mayor, Seán Lyons, David Duffy* and *Richard S.J. Tol*
263	Comparing Poverty Indicators in an Enlarged EU *Christopher T. Whelan* and *Bertrand Maître*
262	Fuel Poverty in Ireland: Extent, Affected Groups and Policy Issues *Sue Scott, Seán Lyons, Claire Keane,* Donal McCarthy and *Richard S.J. Tol*
261	The Misperception of Inflation by Irish Consumers *David Duffy* and *Pete Lunn*
260	The Direct Impact of Climate Change on Regional Labour Productivity Tord Kjellstrom, R Sari Kovats, Simon J. Lloyd, Tom Holt, *Richard S.J. Tol*
259	Damage Costs of Climate Change through Intensification of Tropical Cyclone Activities: An Application of FUND Daiju Narita, *Richard S. J. Tol* and *David Anthoff*
258	Are Over-educated People Insiders or Outsiders? A Case of Job Search Methods and Over-education in UK Aleksander Kucel, *Delma Byrne*
257	Metrics for Aggregating the Climate Effect of Different Emissions: A Unifying Framework *Richard S.J. Tol,* Terje K. Berntsen, Brian C. O'Neill, Jan S. Fuglestvedt, Keith P. Shine, Yves Balkanski and Laszlo Makra
256	Intra-Union Flexibility of Non-ETS Emission Reduction Obligations in the European Union *Richard S.J. Tol*
255	The Economic Impact of Climate Change *Richard S.J. Tol*
254	Measuring International Inequity Aversion *Richard S.J. Tol*
253	Using a Census to Assess the Reliability of a National

Household Survey for Migration Research: The Case of Ireland
Alan Barrett and *Elish Kelly*

252 Risk Aversion, Time Preference, and the Social Cost of Carbon
David Anthoff, Richard S.J. Tol and Gary W. Yohe

251 The Impact of a Carbon Tax on Economic Growth and Carbon Dioxide Emissions in Ireland
Thomas Conefrey, John D. Fitz Gerald, Laura Malaguzzi Valeri and *Richard S.J. Tol*

250 The Distributional Implications of a Carbon Tax in Ireland
Tim Callan, Sean Lyons, Susan Scott, Richard S.J. Tol and Stefano Verde

249 Measuring Material Deprivation in the Enlarged EU
Christopher T. Whelan, Brian Nolan and *Bertrand Maître*

248 Marginal Abatement Costs on Carbon-Dioxide Emissions: A Meta-Analysis
Onno Kuik, Luke Brander and *Richard S.J. Tol*

247 Incorporating GHG Emission Costs in the Economic Appraisal of Projects Supported by State Development Agencies
Richard S.J. Tol and *Seán Lyons*

246 A Carton Tax for Ireland
Richard S.J. Tol, Tim Callan, Thomas Conefrey, John D. Fitz Gerald, Seán Lyons, Laura Malaguzzi Valeri and *Susan Scott*

245 Non-cash Benefits and the Distribution of Economic Welfare
Tim Callan and *Claire Keane*

244 Scenarios of Carbon Dioxide Emissions from Aviation
Karen Mayor and *Richard S.J. Tol*

243 The Effect of the Euro on Export Patterns: Empirical Evidence from Industry Data
Gavin Murphy and *Iulia Siedschlag*

242 The Economic Returns to Field of Study and Competencies Among Higher Education Graduates in Ireland
Elish Kelly, Philip O'Connell and *Emer Smyth*

241 European Climate Policy and Aviation Emissions
Karen Mayor and *Richard S.J. Tol*

240	Aviation and the Environment in the Context of the EU-US Open Skies Agreement *Karen Mayor* and *Richard S.J. Tol*
239	Yuppie Kvetch? Work-life Conflict and Social Class in Western Europe *Frances McGinnity* and *Emma Calvert*
238	Immigrants and Welfare Programmes: Exploring the Interactions between Immigrant Characteristics, Immigrant Welfare Dependence and Welfare Policy *Alan Barrett* and Yvonne McCarthy
237	How Local is Hospital Treatment? An Exploratory Analysis of Public/Private Variation in Location of Treatment in Irish Acute Public Hospitals *Jacqueline O'Reilly* and *Miriam M. Wiley*
236	The Immigrant Earnings Disadvantage Across the Earnings and Skills Distributions: The Case of Immigrants from the EU's New Member States in Ireland *Alan Barrett*, *Seamus McGuinness* and *Martin O'Brien*
235	Europeanisation of Inequality and European Reference Groups *Christopher T. Whelan* and *Bertrand Maître*
234	Managing Capital Flows: Experiences from Central and Eastern Europe Jürgen von Hagen and *Iulia Siedschlag*
233	ICT Diffusion, Innovation Systems, Globalisation and Regional Economic Dynamics: Theory and Empirical Evidence Charlie Karlsson, Gunther Maier, Michaela Trippl, *Iulia Siedschlag,* Robert Owen and *Gavin Murphy*
232	Welfare and Competition Effects of Electricity Interconnection between Great Britain and Ireland *Laura Malaguzzi Valeri*
231	Is FDI into China Crowding Out the FDI into the European Union? Laura Resmini and *Iulia Siedschlag*
230	Estimating the Economic Cost of Disability in Ireland John Cullinan, Brenda Gannon and *Seán Lyons*
229	Controlling the Cost of Controlling the Climate: The Irish Government's Climate Change Strategy Colm McCarthy, *Sue Scott*

228 The Impact of Climate Change on the Balanced-Growth-Equivalent: An Application of *FUND*
David Anthoff, *Richard S.J. Tol*

227 Changing Returns to Education During a Boom? The Case of Ireland
Seamus McGuinness, *Frances McGinnity, Philip O'Connell*

226 'New' and 'Old' Social Risks: Life Cycle and Social Class Perspectives on Social Exclusion in Ireland
Christopher T. Whelan and *Bertrand Maître*

225 The Climate Preferences of Irish Tourists by Purpose of Travel
Seán Lyons, Karen Mayor and *Richard S.J. Tol*

224 A Hirsch Measure for the Quality of Research Supervision, and an Illustration with Trade Economists
Frances P. Ruane and *Richard S.J. Tol*

223 Environmental Accounts for the Republic of Ireland: 1990-2005
Seán Lyons, Karen Mayor and *Richard S.J. Tol*

2007 222 Assessing Vulnerability of Selected Sectors under Environmental Tax Reform: The issue of pricing power
J. Fitz Gerald, M. Keeney and *S. Scott*

221 Climate Policy Versus Development Aid
Richard S.J. Tol

220 Exports and Productivity – Comparable Evidence for 14 Countries
The International Study Group on Exports and Productivity

219 Energy-Using Appliances and Energy-Saving Features: Determinants of Ownership in Ireland
Joe O'Doherty, *Seán Lyons* and *Richard S.J. Tol*

218 The Public/Private Mix in Irish Acute Public Hospitals: Trends and Implications
Jacqueline O'Reilly and *Miriam M. Wiley*

217 Regret About the Timing of First Sexual Intercourse: The Role of Age and Context
Richard Layte, Hannah McGee

216 Determinants of Water Connection Type and Ownership of Water-Using Appliances in Ireland
Joe O'Doherty, *Seán Lyons* and *Richard S.J. Tol*

215 Unemployment – Stage or Stigma?

	Being Unemployed During an Economic Boom *Emer Smyth*
214	The Value of Lost Load *Richard S.J. Tol*
213	Adolescents' Educational Attainment and School Experiences in Contemporary Ireland *Merike Darmody, Selina McCoy, Emer Smyth*
212	Acting Up or Opting Out? Truancy in Irish Secondary Schools *Merike Darmody, Emer Smyth* and *Selina McCoy*
211	Where do MNEs Expand Production: Location Choices of the Pharmaceutical Industry in Europe after 1992 *Frances P. Ruane*, Xiaoheng Zhang
210	Holiday Destinations: Understanding the Travel Choices of Irish Tourists *Seán Lyons, Karen Mayor* and *Richard S.J. Tol*
209	The Effectiveness of Competition Policy and the Price-Cost Margin: Evidence from Panel Data Patrick McCloughan, *Seán Lyons* and William Batt
208	Tax Structure and Female Labour Market Participation: Evidence from Ireland *Tim Callan*, A. Van Soest, *J.R. Walsh*