Climatically Corrected Energy Consumption - An Empirical Analysis of the Danish Manufacturing and Residential Sectors

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Abstract: When modelling energy demand relationships variables representing some kind of heating degree index (and/or cooling degree index) are often included when using e.g. regression analysis. In connection with the production of energy consumption data, these are often corrected for climatic influences - especially when residential consumption is concerned as weather conditions influence heavily on heat consumption - e.g. by using a constant temperature elasticity of reasonable magnitude. Analysing energy data for the Danish economy, the heating degree index is found significant in the short run dynamics of the energy consumption models, but - more surprisingly - it also seems to influence especially industrial energy consumption more than usually assumed. Additionally, the climate variations seem to influence the long run levels of energy consumption.

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1. INTRODUCTION

When modelling energy demand - and empirically testing these models - the influence of climate changes on energy consumption is usually picked up by e.g. inclusion of some kind of heating degree index in the model. In most cases annual variations in climatic conditions seem to influence the energy consumption significantly, cf. Bopp (1984), Bentzen & Engsted (1993a), Engsted & Bentzen (1993b), Madlener & Alt (1996), where especially the usage of energy for heating purposes may be sensitive to the weather conditions.

The purpose of this paper is to analyse the influence of climatic conditions on manufacturing and residential energy consumption in Denmark. Both short-run and long-run influences will be analysed using a 'data driven' approach in the context of single-equation modelling of energy demand. Using time series data for the Danish manufacturing and residential sectors, in the period 1960-1994, an empirical - or 'data driven' - approach is used when analysing the question of how to deal with the temperature variable in an energy demand relationship. The statistical modelling technique used is the cointegration and error-correction approach which is suitable when variables are non-stationary, i.e. I(1). As expected, the heating degree index is found to be significant in the short-run dynamics of the residential energy consumption models but - more surprisingly - it also seems to influence industrial energy consumption more than usually assumed. Additionally, the long run temperature elasticity is found to be approximately unity in residential energy demand whereas there does not seem to be a similar connection between the temperature variable and industrial energy consumption.

The first part of the paper deals with the data set and gives a short graphical description of the development in energy consumption and a preliminary analysis concerning short-run correlations between the heating degree index (i.e. weather conditions) and manufacturing/residential energy consumption. Then single-equation models of energy demand are estimated in order to investigate the most appropriate way to handle the temperature variable in regression analysis. Time series data covering the period 1960-1994 for the Danish industrial and residential sectors are used and both the Engle-Granger OLS method and the multivariate Johansen procedure will be applied to these data.

2. THE DEVELOPMENT IN MANUFACTURING AND RESIDENTIAL ENERGY CONSUMPTION

Data representing energy consumption, real income and real energy prices are used when analysing manufacturing and residential energy demand. All data concerning energy consumption are obtained from the *Energy Balances of OECD-Countries (OECD 1996)* where the annual consumption data are available as 'final consumption', i.e. after deduction of conversion and distribution losses. Data concerning income and prices are from the database of the Danish macroeconometric model *ADAM*, and data for the heating degree index are calculated using monthly temperature data from *Statistics Denmark*. The following variables are used in the analysis:

Em: total final energy consumption (TFC) in the manufacturing sector, measured as tonnes of oil equivalents (Source: OECD Energy Balances).

Er: total final energy consumption (TFC) in the residential sector, measured as tonnes of oil equivalents (Source: OECD Energy Balances).

Ym: GDP for the manufacturing sector, measured in thenational currency and 1990 prices (Source: OECD, CDR 1996-vers.)

Yr: Real disposable income in the private sector, measured in the national currency and 1990 prices (Source: ADAM, Danish macroeconometric model, 1996-vers.)

Pr: Real energy price, calculated as the consumer price index for fuels, electricity and district heating deflated by the CPI (Source: Statistics Denmark, Statistical Yearbook, var. issues). Used in connection with the analysis of the residential sector.

Pw: The price of oil products (measured in import prices) deflated by the wage rate of industrial workers. (Source: The Danish macroeconometric model ADAM). Used in connection with the analysis of the manufacturing sector.

Pc: The price of oil products (measured in import prices) deflated by a price index of industrial investment goods. (Source: The Danish macroeconometric model ADAM).

T: The heating degree index - where an increase in the value of the index represents a cold winter (heating season). (Source: *Statistics Denmark*, Statistical Yearbook, var. issues, and own calculations).

The data for total final energy consumption (E) have been slightly corrected. As regards energy consumption in the manufacturing sector there have been significant changes concerning the usage of different energy sources during the last two decades. Especially the share of oil used for final energy consumption purposes has decreased in relation to other fuels or energy sources like e.g. electricity. As the conversion losses in connection with electricity production (from primarily oil and coal) are placed outside the manufacturing sector a shift from oil to electricity will cause a decline in consumption when this is measured on a 'final' basis. Contrary to this, if energy consumption is calculated in terms of primary fuels alone there need not be such a decline in manufacturing energy consumption. Hence, manufacturing electricity consumption has been corrected to approximate the content of primary fuels. In the OECD *Energy Balances* for residential energy consumption, data for electricity consumption are missing for the sub-period 1960-1972. Fortunately, data for total electricity consumption in the Danish economy are available and for the 1970's approximately 40% is consumed in the residential sector. Using this information the final energy consumption in the residential sector has been corrected upwards with 40% of the total electricity consumption for the period 1960-1972.

The real oil price as defined above is only a rough measure or proxy for manufacturing energy prices, but as very few data are available for the 1960s and 1970s the abovementioned variables Pw and Pc will be used in the analysis. Besides, industrial energy consumption has not been subject to taxation and therefore import prices of oil fuels may be a reasonable proxy for prices of many energy products used by the manufacturing sector.

The development of the total final energy consumption in the manufacturing and the residential sectors is depicted in figure 1.

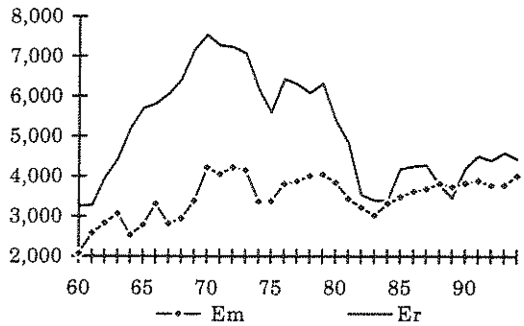

Figure 1. Final energy consumption, manufacturing and residential sectors, Denmark 1960-1994 (Ktoe).

More than two decades have now passed since the first oil price shock and many substitution processes in both energy production and energy consumption have taken place which is clearly reflected in figure 1 where an increase in energy consumption takes place until the beginning of the 1970s and from that time on the level of energy consumption more or less stabilizes - or even declines in the case of residential energy consumption. Figure 2 depicts energy prices as defined in the first part of this section.

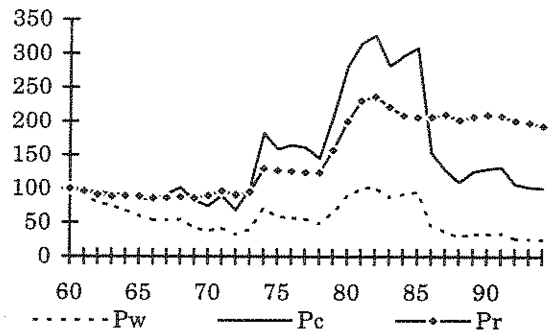

Figure 2. Real energy prices, 1960-1994 (Index 1960 = 100).

The first two oil price shocks are clearly reflected in the development of energy prices and - in Denmark - the collapse in oil prices in 1985-86 was accompanied by increased energy taxation which kept real consumer prices at approximately the same level. Industrial energy consumption has been exempted from taxation which is clearly reflected in falling real energy prices in 1986.

Figure 3 and Figure 4 present plots of changes in energy consumption versus changes in the heating degree index (calculated as first-differences to the log values) which might be expected to show positive correlation.

The positive correlation coefficients are also both found to be highly significant and with this result it must be expected that - at least in the short run - the temperature variable is of importance when modelling energy demand.

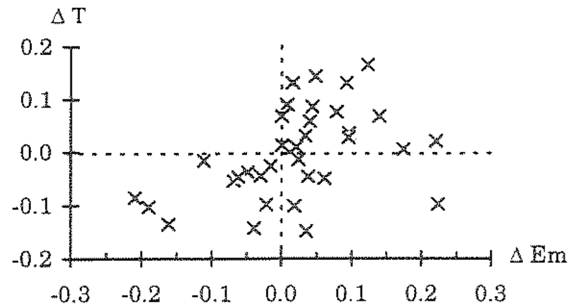

Figure 3. Energy consumption vs. heating degree index, annual rates of change, manufacturing sector.

Note: Correlation coefficient = 0.44 (p-value=0.01).

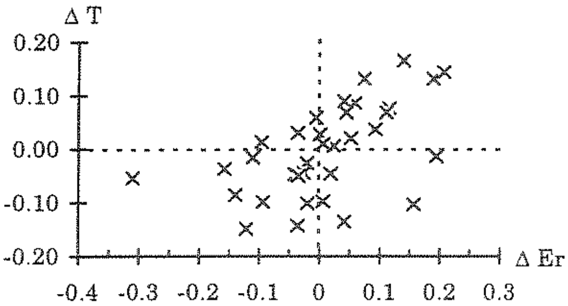

Figure 4. Energy consumption vs. heating degree index, annual rates of change, residential sector.

Note: Correlation coefficient = 0.54 (p-value=0.001).

3. TESTING FOR UNIT ROOTS

Before using the data presented in part 2 when analysing the development in energy consumption, the time series properties of the variables are analysed. Many economic time series variables, e.g. GDP and energy consumption, are often found to be non-stationary in levels and consequently, the Dickey-Fuller and Phillips-Perron stationarity-tests are performed on the variables used here. If these are found to be non-stationary, a necessary condition for the existence of a stable long-run relation between energy consumption and other variables as income and energy prices - which might be used when modelling energy demand - is that they cointegrate. The next step in this analysis is to test for cointegration - or long-run relationships - between oil consumption in the selected European OECD countries.

The DF-test to find out whether a variable X is integrated, I(1), or stationary, I(0), is performed by running the following regression, where t represents a time trend:

$$\Delta X_t = \alpha + \beta t + \varphi X_{t-1} + lags\ of\ \Delta X_t + \varepsilon_t \qquad (1)$$

The test is not carried out with a time trend for all variables as some of the series do not seem to contain a linear trend. Lags of ΔX are included on the right-hand side of (1) in order to whiten the errors. The results of the Dickey-Fuller test for unit roots - and the PP-test with correction for first and third order auto correlation - are shown in table 1.

Table 1. Unit root tests

	ADF {lags}	PP{1}	PP {3}
Em: Manufacturing	-3.35 {0}	-3.53	-3.52
Er: Residential	-3.20 {1}	-2.57	-2.57
Ym: Manufact. GDP	-2.03 {0}	-2.17	-2.38
Yr: Priv. Disp. Income	-2.54 {0}	-2.66	-2.68
Pw: Energy/Wage Ratio	-1.81 {1}	-1.74	-1.83
Pc: Energy/Cap. Ratio	-1.38 {0}	-1.53	-1.58
Pr: Resid. Energy Price	-2.06 {1}	-1.85	-1.94
T: Temperature	-3.64 {0}	-3.80	-3.73

Notes: Log values of the variables used in the tests and the number of observations are 34. A time trend is included in the test except for Pc and T. The critical value at a 5 percent level according to MacKinnon (1991) is -3.55 if a trend is included and -2.95 if no trend is included in (1). { } denotes the included lags in the ADF test.

From all test results in table 1 it can be concluded that none of the variables - except the temperature variable, as expected - seems to be stationary as the null hypothesis of non-stationarity cannot be rejected at the 5% level of significance (although the test value for manufacturing energy consumption is close to this level). Hence, as the variables are non-stationary in levels, they have to be first-differenced in order to become stationary processes (constant unconditional means and variances) unless it can be certified that level values cointegrate, i.e. linear combinations of the variables prove to be stationary indicating stable long-run relationships. The results in table 1 are in accordance with many other energy economics studies using time series data where energy variables are normally best described as non-stationary processes.

4. THE MANUFACTURING SECTOR

In part 3 all variables do seem to contain a stochastic trend (except the temperature variable) even when a linear trend is included in the tests for non-stationarity, and hence the variables representing energy consumption, real income and real energy prices are assumed to be I(1)-variables (it can be verified that first differences are I(0), but test values are not reproduced here). Using the concepts of unit roots and cointegration from the recent time series literature, it is possible to investigate for cointegration among the abovementioned variables.

The two estimating techniques to be used are the Johansen maximum likelihood multivariate procedure and the Engle-Granger two step OLS-procedure. Among the advantages of the Johansen VAR-methodology are first the possibility to detect more than one cointegration relationship - the EG-procedure gives one cointegration vector which eventually may be e.g. a linear combination of more cointegration vectors - and second the possibility formally to test for restrictions on certain variables in the cointegration vector, e.g. an exclusion restriction on certain variables. A further description of the method can be found in Bentzen & Engsted (1993).

Modelling manufacturing energy demand follows Hunt and Lynk (1992) who analyse UK industrial energy demand under the assumption that the long-run cointegration relationship can be expressed as (with variables in log values)

$$log\ Em_t = \alpha + \beta\ trend + \delta\ log\ Ym_t + \omega\ log\ Pw_t + \tau\ log\ Pc_t + \varepsilon_t \quad (2)$$

In this ad hoc formulation of industrial energy demand the explanatory variables are assumed to be output (value-added GDP) and relative factor prices. A time trend is added in (2) to capture autonomous increases in energy efficiency. The double-log form makes the parameters directly interpretable as long run elasticities.

The first step in the analysis is to test for the existence of possible long-run relationships, i.e. cointegration relationships as the variables are non-stationary. In case evidence in favour of cointegration is found, an error-correction model capturing both short run and long run aspects of energy demand is estimated - and in this modelling framework the question or the importance of the temperature variable is discussed.

Following the two-step Engle-Granger methodology - also applied in Hunt and Lynk (1992) for the UK industrial sector - equation (2) is first estimated by OLS and then followed by a stationarity test concerning the residuals. The results are reported in table 2.

Table 2. Cointegration test, manufacturing energy demand, Engle-Granger-procedure.

$\hat{\beta}$	-0.024
$\hat{\delta}$	0.429
$\hat{\omega}$	-0.640
$\hat{\tau}$	0.451
$\bar{R}^2$	0.76
DW	1.31
ADF	-4.51 {1}

Notes: Log values of the variables used in the tests and the number of observations are 35. (An intercept term is included in the regression, but the estimate is not reported). The critical values at the 5% and the 10% levels of significance are -4.86 and -4.47, respectively, according to MacKinnon (1991). { } denotes the included lags in the ADF test.

The ADF-test for cointegration has a value of -4.51 which is just above the 10% level of significance level. Consequently the residuals from (2) may be a stationary process and hence, the estimated parameter values in table 2 represent a stable, long-run cointegration relationship. The output and trend variables both have the expected sign and from the signs of the price parameter estimates it seems that energy and labour are substitutes whereas energy and capital seem to be complements.

In order to apply an alternative test methodology the multivariate Johansen procedure has been applied to the same data. In this case the temperature variable has been added to the short-run dynamics in the VAR-approach related to this method. Table 3 reports the two test statistics - the so-called Max and Trace tests.

In table 4 the conclusion concerning the number of cointegration vectors is the same according to both the Max test and the Trace test, i.e. one vector is well within the 5% level of significance as both the hypotheses of two vectors (Max test) and more than one vector (Trace test) are rejected. Hence, only one cointegration vector is assumed to be present.

Table 3. Cointegration test, manufacturing energy demand, Johansen-procedure.

Rank	L_{MAX}	L_{TRACE}
r = 0	36.12*	78.36*
r ≤ 1	21.23	42.23
r ≤ 2	12.29	21.00
r ≤ 3	8.71	8.71

Estimated cointegration vector:

log Em	log Ym	log Pw	log Pc	trend
1	-0.595	0.185	0.092	0.018

Notes: The VAR is estimated with lags=1 as annual data are used and the number of observations are 35. The temperature variable is included in the short-run dynamics of the testing procedure. * denotes significant at a 5% level, with critical values from Osterwald-Lenum (1992). Signs are reversed compared with the OLS parameter estimates in table 2, e.g. the output elasticity is +0.595 (similar to the OLS estimate of 0.429).

Like before, the output and trend estimates have the expected sign and are quite close to the results presented in table 2. As regards the price variables the results from the Johansen analysis differ from the OLS-estimates and show comparatively small relative factor price elasticities (and with the opposite sign as regards the energy-capital price ratio). Therefore the procedure will be to estimate error-correction models - and including the temperature variable - using both cointegration vectors, respectively.

The error-correction model is given as equation (3) where lags of first-differenced variables (log values) may be included (higher order lags may also be considered, but with annual data these will often be insignificant)

$$\Delta Em_t = \alpha + \beta T_t (or\ \Delta T_t) + \delta \Delta Ym_t + \omega \Delta Pw_t + \tau \Delta Pc_t + \varphi \Delta Em_{t-1} + \gamma ECM_{t-1} + \varepsilon_t \quad (3)$$

The ECM term is given as the formerly estimated stationary long-run relationship from the cointegration analysis, lagged one period.

The results of using the cointegration vectors from table 2 and table 3 turn out to perform well in both cases. In order to further analyse the influence of the temperature variable on energy consumption, two versions of the ECM are estimated - where the first-differences and level values of the heating degree index, respectively, are added to the model. For the OLS cointegration vector the results are reported in table 4 and for the Johansen vector the results are found in table 5.

After deleting insignificant parameter estimates - using a 5% level of significance - the final models are somewhat reduced which is evident from table 4 and table 5, e.g. the short-run output elasticity (the parameter to the ΔY-variable) turns out to be insignificant in both cases. The parameter estimates to the error-correction terms are highly significant with the 'correct' signs which may be interpreted as evidence in favour of a cointegration hypothesis and application of an error-correction model to the data. The error-correction terms are higher if the EG-cointegration vector is applied (table 4) indicating that if industrial energy is off the long run demand curve adjustment takes place relatively fast (0.7-0.8 of the adjustment takes place the first year).

Table 4. Error-correction model, residential sector, coint. vector from EG-procedure.

$$\Delta Em_t = -2.41^* + 0.43^* T_t - 0.10^* \Delta Pc_t + 0.26^* \Delta Em_{t-1} - 0.84\ ECM_{t-1}$$
(-2.15) (3.16) (2.16) (2.32) (-5.61)

$\bar{R}^2 = 0.62$ DW = 1.91

$$\Delta Em_t = 0.89^* + 0.44^* \Delta T_t - 0.13^* \Delta Pc + 0.34^* \Delta Em_{t-1} - 0.69^* ECM_{t-1}$$
(4.66) (3.59) (-2.75) (3.11) (-4.61)

$\bar{R}^2 = 0.65$ DW = 2.23

Notes: t-values in parenthesis, * significant at the 5% level, ** significant at the 10% level. Variables in log values.

Table 5. Error-correction model, manufacturing sector, coint. vector from Johansen-procedure.

$$\Delta Em_t = -2.06 + 0.31^{**} T_t - 0.15^* \Delta Pc_t - 0.38^* ECM_{t-1}$$
(-1.50) (1.81) (-2.41) (-4.01)

$\bar{R}^2 = 0.44$ DW = 1.58

$$\Delta Em_t = 0.38^* + 0.41^* \Delta T_t - 0.15^* \Delta Pc_t - 0.36\ ECM_{t-1}$$
(4.20) (2.84) (2.74) (-4.01)

$\bar{R}^2 = 0.51$ DW = 1.68

Notes: t-values in parenthesis, * significant at the 5% level, ** significant at the 10% level. Variables in log values.

Regarding the ECM in table 4 there is no difference between the results if first-difference values (ΔT) or level values (T) are included in the regressions. Hence, this simple 'data-driven' approach does not answer the question which version of the heating degree index to use. But in both cases the short run temperature elasticity is estimated to be about 0.44 which is somewhat more than usually assumed (only a smaller part of Danish industrial energy consumption is assumed to be influenced by climate conditions). The temperature elasticity is found to be highly significant which may be taken as further evidence regarding the necessity of taking temperature variables into consideration when modelling energy demand and also when producing the so-called 'climatically corrected' energy statistics.

In the ECM-version with level values of the T-variable a long-run temperature elasticity can be calculated as the error-correction term consists of level values of energy consumption, output and energy prices. In the long-run all first-differences vanish from the ECM and hence the long run temperature elasticity can be calculated as $\hat{\beta}/\hat{\gamma}$ and with the parameter estimates from table 4 this gives an elasticity of 0.55 - which is close to the short-run temperature elasticity.

Now turning to the results in table 5, the estimated ECMs does not seem to fit as well as the model including the OLS/EG cointegration vector as the degree of explanation (R^2) is poorer and the DW-value somewhat lower, especially in the case including the T (level) variable. The short-run temperature elasticity is found to be in the range 0.3 to 0.4 which is in accordance with the previous results, but a hypothesis of a long run relationship with the temperature variable is not convincingly supported as the T-variable is not found to be significant at a 5% level and the model has a relatively low R^2- value (0.44) - with the reported parameter estimates the long-run temperature elasticity will be about unity which certainly is deviating from the former result (0.55).

The conclusion seems to be that climate conditions do influence industrial energy consumption in the short run with a temperature elasticity of approximately 0.4 and that the data - applied to the simple modelling procedure here - do no allow any final conclusions about a possible level of the long run temperature elasticity.[1]

5. THE RESIDENTIAL SECTOR

Analysing residential energy consumption is done similarly to the procedure presented in part 4. The single-equation double-log model from equation (2) - with the necessary changes on the right hand side, i.e. real disposable income (Yr) and real energy price (Pr) included - is assumed to represent consumer demand. In this case the model may be argued to fit the economic theory better as equation (4) represents an iso-elastic version of a demand relation including the traditional income and price variables from consumer theory

$$Er = \alpha \exp(\beta t)\, Yr^{\delta}\, Pr^{\omega} \qquad (4)$$

Taking logs on both sides of (4) and adding an error term gives the long-run demand relationship to be estimated

$$Log\ Er_t = log\ \alpha + \beta\ trend + \delta \log Yr_t + \omega \log Pr_t + \varepsilon_t \qquad (5)$$

The inclusion of a time trend in (5) will eventually capture increases in energy efficiencies (the trend will then show up with a negative parameter value) which can be expected to be caused by better insulation of dwellings, better heating techniques, etc. Looking at the data for residential energy consumption presented in figure 1 such a development seems to be true, but - most surprisingly - in all the attempts to estimate (5) the time trend does not seem to be of any importance. In the Johansen procedure the significance of the parameters to include in the cointegration vector can be directly tested and the hypothesis of an excluded time trend cannot be rejected. Hence, the variables real income and real energy prices alone are able to explain the actual development in residential energy consumption. The results of the OLS/EG-procedure are found in table 6.

Table 6. Cointegration test, residential energy demand, Engle-Granger-procedure.

$\hat{\delta}$	1.278
$\hat{\omega}$	-0.956
$\bar{R}^2$	0.68
DW	0.74
ADF	-3.19 {1}

Notes: Log values of the variables used in the tests and the number of observations are 35. (An intercept term is included in the regression, but the estimate is not reported). The critical values at the 5% and the 10% levels of significance are -4.47 and -4.10, respectively, according to MacKinnon (1991). { } denotes the included lags in the ADF test.

[1] As explained in part 2 the data concerning manufacturing energy consumption have been corrected with regard to electricity consumption (approximately recalculated in primary energy terms). Applying the same modelling and regression techniques as presented here in part 4 to the original data does only influence marginally on the final models and parameter estimates and therefore the conclusions seem robust concerning the 'data mining' procedure.

The cointegration vector reported in table 6 has the correct sign for the long-run income and price elasticities and from an economic point of view the unitary elasticities also seem to be very likely values for these parameters. The ADF-test value is below the 10% level of significance and consequently the hypothesis of non-cointegration cannot be rejected. Therefore the next step in the analysis is to see whether the Johansen procedure presents different results.

Table 7. Cointegration test, manufacturing energy demand, Johansen-procedure.

Rank	L_{MAX}	L_{TRACE}
r = 0	40.42*	54.35*
r ≤ 1	7.19	13.93
r ≤ 2	6.74	6.74
Estimated cointegration vector:		
log Er	log Yr	log Pr
1	-1.276	1.000

Notes: The VAR is estimated with lags=1 as annual data are used and the number of observations are 35. The temperature variable is included in the short-run dynamics of the testing procedure. * denotes significant at a 5% level, with critical values from Osterwald-Lenum (1992).

In table 7 the conclusion regarding the number of cointegration vectors is the same according to both the Max test and the Trace test, i.e. one vector well within the 5% level of significance as both the hypotheses of two vectors (Max test) and more than one vector (Trace test) are rejected. Hence one cointegration vector is assumed to be present.

The cointegration vector found according to the Johansen method differs surprisingly little from the OLS-result in table 6. Therefore, the long-run relationship between energy consumption, income and energy prices is assumed to be best described by the relationship reported in table 7 and therefore this is also applied in the error-correction model. Like before all insignificant parameter estimates are step-wise deleted from the regressions and table 8 depicts the final models - estimated with both first-differences and level values of the temperature variable.

Table 8. Error-correction models, residential sector, coint.vector from Johansen-procedure.

$\Delta Er_t = -5.33^* + 0.61^*\ T_t + 0.90^*\ \Delta Y_t - 0.59^*\ ECM_{t-1}$
(-4.99) (4.60) (2.66) (-8.21)
$\bar{R}^2 = 0.73$ DW = 1.87

$\Delta Er_t = -0.37^* + 0.46\ \Delta T_t + 0.56\ \Delta Y_t - 0.49^*\ ECM_{t-1}$
(-5.89) (3.42) (1.51) (-5.91)
$\bar{R}^2 = 0.66$ DW = 1.68

Notes: Although insignificant the short-run income elasticity is kept in the 'ΔT version' as this makes the models equal with regard to the variables included. t-values in parenthesis, * significant at the 5% level, ** significant at the 10% level. Variables in log values.

Like the analysis of manufacturing energy consumption in part 4 the temperature variable again seems to perform well in the model with highly significant values while e.g. the short run price elasticity vanishes because of insignificance. The model including level values of the temperature variable seems to perform best if evaluated with respect to the R^2 and DW-statistics. An adjusted degree of explanation equal to 0.73 is relatively high taking into consideration the few variables in the model!

The short run temperature elasticity is found to be 0.6 which is in accordance with the practise of the Danish Energy Agency who uses an elasticity of 0.5 when correcting residential energy consumption for climatic influences. The long-run temperature elasticity becomes very close to unity (1.02) and this nice result appears also very likely, i.e. a permanent shift in the level of the temperature variable (the climatic conditions) will also shift the level of energy consumption in the same proportion.

6. CONCLUSIONS

The long-run development of industrial and residential energy demand has been analysed with special emphasis on the role of climate influences on energy demand. Applying a relatively simple single-equation models to sectoral energy demand - in the context of cointegration and error-correction modelling - the main conclusion seems to be that in the short run the temperature conditions influence both industrial and residential energy consumption. The short-run temperature elasticity is approximately 0.4 for the industrial sector and 0.5-0.6 in residential energy consumption. In the long run the results are less conclusive, but at least for the residential sector a relation probably exists between the levels of long run energy consumption and the temperature variable - with a unitary elasticity.

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