UNIVERSITY OF CYPRUS
ECONOMICS RESEARCH CENTRE

Economic Policy Papers

The Effect of EU Energy and Climate Policies on the Production Sectors of the Economy of Cyprus – Final Results

Elena Ketteni
Europrism Research, Frederick University and University of Cyprus

Theofanis Mamuneas
Department of Economics, University of Cyprus

Theodoros Zachariadis
Department of Environmental Science & Technology, Cyprus University of Technology

No. 01-13

February 2013

Publication Editor: Christos Koutsampelas

ERC Sponsors (in alphabetical order)

Association of Cyprus Banks

Central Bank of Cyprus

Department of Economics, University of Cyprus

Ministry of Finance

Ministry of Labour and Social Insurance

Planning Bureau

University of Cyprus

The Effect of EU Energy and Climate Policies on the Production Sectors of the Economy of Cyprus – Final Results

Elena Ketteni, Theofanis Mamuneas and Theodoros Zachariadis

Executive Summary

This report summarises work that was carried out in the frame of the research project entitled "Economic Impacts from the Implementation of the European Union's Energy and Climate Change Legislation Package in Cyprus", which is funded by the Research Promotion Foundation of Cyprus in the framework of 'DESMI 2009-2010', a programme co-funded by the Republic of Cyprus and the European Regional Development Fund (project number ΑΕΙΦΟΡΙΑ/ΚΟΙΑΦ/0609(ΒΙΕ)/02).

The European Union's energy and climate policy package, legally adopted in early 2009, will affect the European economy because it will induce an increase in energy prices. In this project we model the effect of this policy package on the economy of Cyprus, a small EU island state. We formulate and estimate econometrically a production model that embodies rational expectations and dynamic optimization, accounting not only for efficiency gains due to investments in energy-saving technology but also for adjustment costs associated with capital, energy and other input replacement. We then simulate changes in factor demand and production costs up to the year 2020. Production costs may grow modestly over the entire economy of Cyprus as a result of the effect of higher energy prices induced by EU policies. Our cost estimates are higher than those calculated by the European Commission when setting the targets of its energy and climate legislation.

CONTENTS

Επιπτώσεις στους Παραγωγικούς Τομείς της Κυπριακής Οικονομίας από την Εφαρμογή της Ευρωπαϊκής Πολιτικής για την Ενέργεια και την Κλιματική Αλλαγή

Έλενα Κεττένη, Θεοφάνης Μαμουνέας και Θεόδωρος Ζαχαριάδης

ΠΕΡΙΛΗΨΗ

Το παρόν Δοκίμιο συνοψίζει εργασία που διενεργήθηκε στο πλαίσιο του έργου με αρ. πρωτοκόλλου ΑΕΙΦΟΡΙΑ/ΚΟΙΑΦ/0609(ΒΙΕ)/02, το οποίο χρηματοδοτείται από το Ίδρυμα Προώθησης Έρευνας στο πλαίσιο της «Δέσμης Προγραμμάτων 2009-2010» που υποστηρίζεται χρηματικά από την Κυπριακή Δημοκρατία και το Ευρωπαϊκό Ταμείο Περιφερειακής Ανάπτυξης.

Η νομοθεσία για την ενέργεια και την κλιματική αλλαγή, που υιοθετήθηκε το 2009 από την Ευρωπαϊκή Ένωση, αναμένεται να έχει επιπτώσεις στην κυπριακή οικονομία επειδή θα οδηγήσει σε αύξηση των λιανικών τιμών σε ορισμένα ενεργειακά προϊόντα και σε πιθανή επακόλουθη αύξηση των τιμών και σε άλλα αγαθά και υπηρεσίες. Για τη διερεύνηση των επιπτώσεων αυτών, αναπτύχθηκε ένα θεωρητικό μοντέλο παραγωγής της κυπριακής οικονομίας και εκτιμήθηκε οικονομετρικά με βάση δεδομένα που συυλέχθηκαν από επίσημες στατιστικές πηγές για τον σκοπό αυτό. Στη συνέχεια, προσομοιώθηκαν δύο συγκεκριμένα σενάρια μεταβολής των τιμών της ενέργειας μέχρι το 2020. Η ανάλυσή μας οδηγεί στα εξής συμπεράσματα:

1. Εξαιτίας της αύξησης των ενεργειακών τιμών (προπαντός στον ηλεκτρισμό και δευτερευόντως στα καύσιμα κίνησης), και παίρνοντας υπόψη τον περιορισμό στην κατανάλωση ενέργειας και τις αλλαγές στη ζήτηση άλλων συντελεστών παραγωγής ανά παραγωγικό τομέα, κατά το έτος 2020 το συνολικό κόστος παραγωγής της οικονομίας αναμένεται να αυξηθεί κατά 23 εκ. Ευρώ (σε τιμές του 2010).

2. Μολονότι το κόστος αυτό σε απόλυτα μεγέθη δεν είναι ασήμαντο, η αύξηση του *μοναδιαίου* κόστους παραγωγής προβλέπεται να είναι χαμηλή (κάτω από 3 Ευρωσέντς), με συνέπεια οι επιπτώσεις στην ανταγωνιστικότητα της οικονομίας να είναι πολύ μικρές. Επίσης, δεν αναμένεται να επηρεασθούν αισθητά οι επενδύσεις και η απασχόληση στην ευρύτερη οικονομία.

3. Το ανωτέρω κόστος είναι συγκρίσιμο με (και συχνά χαμηλότερο από) το κόστος που προκαλείται στην κυπριακή οικονομία από τη διακύμανση των διεθνών τιμών της ενέργειας για λόγους ανεξάρτητους της όποιας ενεργειακής και περιβαλλοντικής πολιτικής.

1. INTRODUCTION

The effect of energy on the economy has received increasing attention in recent years due to the growing importance of energy security issues and the environmental impacts of energy use. The questions whether energy and other production factors are complements or substitutes, how energy prices affect productivity, what are the economic implications of energy efficiency policies, or whether there is causality between energy consumption and economic output have been addressed in numerous empirical studies which have led to contradictory findings. Our project aims to contribute to this discussion by examining the effect of the legislative package on energy and climate change, which was adopted in the European Union (EU) in early 2009, on the economy of one of its Member states.

This package involves several legally binding measures that aim at reducing greenhouse gas (GHG) emissions in the EU by the year 2020. It envisages a reduction of carbon dioxide (CO_2) emissions of energy intensive industries by 21% in 2020 compared to 2005, to be realized through participation of these industries in the EU Emissions Trading System (EU ETS) with most of the emission permits purchased in auctions; a further decrease of GHG emissions from all other sectors not included in the EU ETS, e.g. the residential sector and transportation; and a considerable increase in the share of renewable energy sources in each country's energy mix, with an additional mandate for a minimum 10% share of renewable fuels in the total consumption of automotive fuels.

This group of measures will substantially affect the economies of EU countries – households, firms and the public sector. The European Commission, the EU's executive body, has conducted an economy-wide analysis of the impacts of this legislative package, which included calculations of the costs of compliance with the policy targets carried out with partial and general equilibrium models (Capros et al. 2011). According to this assessment, the compliance cost to meet both GHG reduction and renewable targets was estimated to range between 0.4% and 0.6% of the EU's GDP in year 2020. An independent assessment of the same policy package, carried out with three different computable general equilibrium (CGE) models, concluded that the costs would most likely be considerably higher than those assessed by the European Commission (Böhringer et al. 2009). At the same time, several EU governments have expressed scepticism about these economic impact assessments, often claiming that the total cost of these measures might be significantly higher in some countries. In the case of Cyprus, a small island state in the Eastern Mediterranean that became an EU member in the year 2004, a preliminary review of Zachariadis and Shoukri (2011) found that the most probable direct effects from the implementation of EU's energy and climate policies are twofold. First, a considerable increase in end-user prices of electricity is expected as a result of the stronger penetration of renewable energy sources and the participation of power utilities in the EU ETS with the obligation to purchase emission permits – whose cost will then be passed through to consumers. Second, a modest increase in the prices of automotive fuels is likely because of the obligations to use an increasing fraction of renewable fuels (mainly biofuels) in transportation.

To analyze the economic effects of such price changes, it should be kept in mind that the impact of energy on productivity and economic growth has always been a controversial subject. According to Berndt (1991), energy price changes have a much larger impact on productivity measures compared to what would be expected on the basis of energy cost shares, because energy price increases spill over to affect real capital inputs as well. Some studies concluded that an increase in the price of electricity stimulates technical change, while others found that increases in the relative price of energy result in reduced productivity growth, Berndt and Hesse (1986). As regards the substitutability between energy and other factors of production, most of the literature found that energy and capital are complements – at least in the short run – and therefore that increases in energy prices would result in lower growth (Apostolakis 1990; Berndt and Wood, 1979; Frondel and Schmidt 2002; Koetse et al. 2008).

The effect of technological progress on energy efficiency is also important in this respect. Judson et al. (1999) estimated time effects that show rising energy consumption over time in households but flat to declining effects in industry and construction, suggesting that technical innovations tend to introduce more energy-using appliances in households and energy-saving techniques in industry. Technology may also affect total factor productivity (TFP). For example, Jorgenson (1984) found that technical change was biased and tended to be energy-using; if this is the case, lower energy prices tend to accelerate TFP growth and vice versa. Summarizing the findings of empirical research on the existence and direction of causality between energy use and economic growth, Stern (2011) notes that the relationship between energy use and aggregate GDP is not simple to identify as it can be affected by other factors such as the substitution between energy and other inputs, technological change, shifts in the composition of energy inputs, shifts in the composition of output as well as environmental implications from the production and use of energy.

Starting from such considerations, we model the effect of the EU's energy and climate policy package on the economy of Cyprus. We first formulate and estimate econometrically a production model for the country, based on the work of Bernstein et al. (2004), which embodies rational expectations and dynamic optimization in the presence of efficiency gains and adjustment costs. As will be explained in Section 2, such a model specification provides the appropriate framework to assess the effect of energy prices on sectoral production costs and input demand because it accounts for the fact that energy is closely tied with energy-using technology. Hence investments in new capital, e.g. in energy-saving technology, do not simply lead to efficiency gains; they also involve adjustment costs in the short run. In contrast to other modeling approaches, we do not distinguish between fixed and variable production factors; in our specification, whether each production factor is variable or not is tested empirically. To our knowledge, this is the first energy-related study that uses this modeling framework.

We find that efficiency gains arise from new electricity and fuel inputs, and these gains are not entirely offset by adjustment costs. We also find, in line with earlier literature, that labor and capital are complements with energy. Using the above mentioned price increases as an input to our empirically estimated model, we perform simulations of changes in demand for factors of production and production costs in year 2020 as a result of these assumptions. An increase in the price of electricity will rise production costs modestly in all sectors of the Cyprus economy; it seems, however, that these increases are comparable in magnitude to fluctuations of energy prices during the last decade that have occurred irrespective of environmental policies. Specifically, the extra cost from the baseline scenario was estimated to be 0.12% of the GDP, while for the high impact scenario 0.18%.

The next Section summarizes the available literature on the interaction between energy, productivity and economic output. Section 3 describes the theoretical model we developed and its empirical specification. The data we collected and used are presented in Section 4. The econometric estimation results are discussed in Section 5, while Section 6 describes the policy simulations performed with the empirical model. Section 7 concludes, offers policy recommendations and outlines future research paths.

2. THE MODEL

In order to examine how changes in energy prices affect investment behavior, employment, productivity and energy use it is essential to employ a dynamic model. Ideally, a dynamic factor demand model should retain the generality of its functional form but should also embody rational expectations and dynamic optimization in the presence of efficiency gains and adjustment costs.

A model that takes into account indirect effects permits energy price increases to have a much larger impact on productivity measures than is indicated by the energy cost shares, as energy price increases spill over to affect real capital as well. When energy price shocks occur, utilization rates of the various surviving vintages of capital adapt, and this also affects the flow of services per unit of capital. If, for example, energy and capital are at least short run complements, then increased energy prices will cause the marginal product of capital – and thus capital utilization – to decline. Not only would this cause efficiency to be suppressed, it would also cause errors in standard measures of technical change. This in turn would cause diminished technical change through reduced incentives to invest in new equipment that embodies new technology. Other scale effects due to fixities not reflected in measured inputs may also cause changes in the overall efficiency of production. In addition, the composition of output and capital would likely be affected. Thus, the impact of energy price changes is difficult to identify without an appropriate modeling framework of a firm's production decisions and performance.

The assumption of instantaneous adjustment of all inputs to price changes may not be very useful under sharp and unexpected increases in the energy prices. In such cases the characteristics of short run behavior may differ from those when full adjustment to long run equilibrium is attained. Dynamic models have been developed along the basic assumption that adjustments of certain quasi-fixed inputs, such as capital, are explicitly taken into account by firms in their production decisions so that adjustment costs become an endogenous part of their firms' total optimization problem.

Based on all the above considerations we will be using a dynamic framework (see e.g. Pindyck and Rotemberg 1983; Morrison 1993), which also incorporates the technical efficiency of energy inputs, as well as other inputs, their costs of adjustment, along with the possibility of substitutability between all inputs under investigation. This framework is sufficiently general and hence enables to capture the effect of input prices on the demands of all inputs under consideration (therefore capturing own and cross price effects of all input prices and demands), and to allow efficiency gains in production to arise when new inputs generate an improvement in technical efficiency that is not fully offset by adjustment cost.

Based on the above considerations, and following Bernstein et al. (2004), we specify a production model for the economy of Cyprus. The model incorporates the possibility that the efficiency of factor additions from physical capital accumulation, intermediate input purchases (materials), fuel and energy inputs or labor hiring, differ from current efficiency levels. Technical efficiency (including adjustment costs) is parameterized directly into the production function, thus adding a dynamic dimension to the problem. One attraction of this model is the parsimonious treatment of efficiency as a single parameter for each input. Efficiency gains in production arise when new inputs generate an improvement in technical efficiency that is not fully offset by costs of adjustment.

We consider the following production function:

$$Y_t = F[(v_{1t-1} + h_1(v_{1t} - v_{1t-1}), \dots, v_{nt-1} + h_n(v_{nt} - v_{nt-1}), t] \tag{1}$$

where y_t is output quantity in period t, F is the production function, v_{it} is the ith input quantity in period t, and t also represents the exogenous disembodied technology index.

Parameters h_i provide for changes in technical efficiency levels related to factor additions. These parameters reflect the variations in "net" efficiency by capturing the gains from factor improvements, and the losses associated with adjustment costs. The value of these parameter are always positive ($h_i > 0$, i = 1,2, …, n).

To understand the role of these parameters, first consider $h_i = 1$. In this case the marginal product of net additions of input i in the current period is the same as that of existing units of the input, and the standard production function emerges. The increased technical efficiency of net additions is being just offset by costs of adjustment.

Next, suppose $h_i > 1$. In this case, the marginal product of net additions of input i in the current period exceeds that of existing units of the input. Accordingly, the benefits from factor improvements dominate adjustment costs incurred through incorporating new inputs into the production process.

Finally, when $0 < h_i < 1$, the marginal product of net additions of input i in the current period is lower than that of existing units of the input. Adjustment costs dominate the benefits associated with factor improvements, and as a result factor additions are less productive than existing inputs.

Factor accumulation is presented by:

$$v_{it} = x_{it} + (1 - \delta_i)v_{it-1} \tag{2}$$

where x_{it} is the addition to the ith input quantity in period t, and $0 \leq \delta i \leq 1$ is the ith input depreciation rate.

Input demands are determined from minimizing the expected present value of acquisition and hiring costs. The expected value is given by the following:

$$\sum_{s=0}^{\infty} \sum_{i=1}^{n} a(t, t+s) q_{it+s}^{e} x_{it+s} \tag{3}$$

where q_{it+s}^{e} is the expectation in the current period t of the ith factor acquisition or hiring price in period $t + s$ and $a(t, t + s)$ is the discount factor.

The expected value is minimized subject to the production function and the factor accumulation equations. Let $p^e_{it+s} = q^e_{t+s} - aq^e_{it+s+1}(1-\delta_i)$ be the *i*th factor price in period t, but expected in period $t+s$, and $a\ = a(t,t+s+1)/a(t,t+s)$ is the constant discount factor.

Bernstein et al. (2004) show that this problem is equivalent to the following problem defined by the cost function:

$$C(w_{1t,}\ldots,w_{nt},y_t,t) = \{\min_{z_t}\sum_{i=1}^{n} w_{it}z_{it}: f(z_{1t},\ldots,z_{nt},t) \gg y_t\} \qquad (4)$$

where $w_{it} = h_i^{-1}\{p_{it} + \sum_{s=1}^{\infty} p^e_{it+s}[(a(1-h_i^{-1})]^s\}$ is the *i*th user cost in period t, and $z_{it} = h_i[v_{it} - (1-h_i^{-1})v_{it-1}]$ is the efficiency-adjusted *i*th input quantity. Note that because of the efficiency parameter h_i the user cost is more general than the traditional factor price. Producers take into account the effect of the efficiency change in current and all future efficiency adjusted marginal products of the inputs. To see this, assume that there is no efficiency change and set the efficiency parameters to unity. With $h_i = 1$ then $p_{it} = q_{it} - aq^e_{it+1}(1-\delta_i)$ which is the traditional factor price.

This equivalence enables us to define a cost function which is denoted as:

$$C(w_{1t},\ldots,w_{nt},y_t,t)$$

Using Shepard's Lemma it is possible to retrieve the efficiency-adjusted factor demands according to:

$$z_i(w_{1t},\ldots,w_{nt},y_t,t) = \frac{\partial C}{\partial w_i}, i = 1,\ldots,n \qquad (5)$$

The efficiency-adjusted factor demands, however, are not observable because the technical efficiency parameters are unknown. Using the definition of the efficiency-adjusted quantity, $z_{it} = h_i(v_{it} - (1-h_i^{-1})v_{it-1})$, the observable factor demands v_{it} can be obtained by

$$v_i(w_{1t},\ldots,w_{nt},y_t,t) = h_i^{-1}\frac{\partial C(w_{1t},\ldots,w_{nt},y_t,t)}{\partial w_{it}} + (1-h_i^{-1})v_{it-1}, i = 1,\ldots,n \qquad (6)$$

These sets of equations form the basis for the estimation model used in our analysis. They depend on user costs (and thereby depreciation and technical efficiency parameters, expected acquisition and hiring prices), on output quantity and on the technology indicator. Therefore, estimation of the above method requires the specification of two elements: the cost function, and the price expectation-generating process for the acquisition and hiring prices.

When doing so, a system can be estimated which includes the factor demand equations derived from the cost function chosen along with the specific price expectation generating process; Bernstein et al. (2004) suggested that the latter is an AR(1) process, but other versions can be used and tested.

The cost function specified is assumed to be the symmetric generalized McFadden functional form introduced by Diewert and Wales (1988). This functional form is attractive because it is flexible and retains its flexibility even under the imposition of concavity with respect to user costs.

$$c_t = (\sum_{i=1}^{n} \beta_i w_{it} + \frac{0.5 \sum_{i=1}^{n} \sum_{j=1}^{n} \beta_{ij} w_{it} w_{jt}}{\sum_{i=1}^{n} b_i w_{it}} + \sum_{i=1}^{n} b_{it} t w_{it} + a_{tt} t^2 \sum\nolimits_{i=1}^{n} b_i w_{it}) y_t + \sum_{i=1}^{n} a_i w_{it} a_t t \sum_{i=1}^{n} b_i w_{it} + a_{yy} y_t^2 \sum_{i=1}^{n} b_i w_{it} \quad (7)$$

where the parameters are denoted by the $\alpha's$ and $\beta's$. The $n \times n$ matrix formed by parameters β_{ij} is symmetric, and must be negative semidefinite so that the function is concave in user costs. Coefficients $bi, i = 1, \ldots, n$ are nonnegative constants that are not all zero for some reference time period τ. For the reference time period, the cost function is homogenous of degree one in user costs if $\sum_{i=1}^{n} \beta_{ij} w_{i\tau} = 0$, and $\sum_{i=1}^{n} b_i w_{i\tau} \neq 0$. The expression $\sum_{i=1}^{n} b_i w_{it}$ is an index of input prices, and the constants $bi, i = 1, \ldots, n$, are set equal to the input cost shares in the reference time period.

Based on the specified cost function (7), and dividing the observable factor demands (6) by output quantity (in order to reduce any possible heteroskedasticity and make calculations with the results more tractable), *i*th input demand per unit of output becomes:

$$\frac{v_i}{y_t} = h_i^{-1} \left\{ \beta_i + \frac{\sum_{j=1}^{n} \beta_{ij} w_{jt}}{\sum_{i=1}^{n} b_i w_{it}} - \frac{.5 b_i \sum_{i=1}^{n} \sum_{j=1}^{n} \beta_{ij} w_{it} w_{jt}}{(\sum_{i=1}^{n} b_i w_{it})^2} + \frac{a_i}{y_t} + \frac{b_i a_t t}{y_t} + b_i a_{tt} t^2 + b_{it} t + b_i a_{yy} y_t \right\} + \left(1 - h_i^{-1}\right) \frac{v_{it-1}}{y_t} \quad (8)$$

Equation (8) allows estimation of the coefficients using observed data. Concavity is also imposed.

The next requirement for estimation involves the expectation generating processes for acquisition and hiring prices. It is assumed that price expectations follow a first order autoregressive process:

$$q_{it+1}^{e} = \varphi_i + \theta_i q_{it} + e_{it}, i = 1, \ldots, n \quad (9)$$

where φ_i and θ_i are parameters, q^e_{it+1} denotes $E_t(q_{it+1})$, e_{it} is identically and independently distributed over time, and since expectations are rational, the expected value of e_{it} is zero. This equation set (9) implies, in the current period *t*, that the *i*th expected acquisition or hiring price in period $t+s$ is

$$q^e_{it+s} = \frac{\varphi_i(1-\theta_i^s)}{(1-\theta_i)} + \theta_i^s q_{it} \tag{10}$$

It is clear from this expression that it is necessary that $\theta_i \neq 1\ \forall i$. However no other condition needs to be imposed on either the sign or the magnitude of the parameters. Combining this equation with the input demand from the minimization of the expected value of acquisition and hiring costs, user costs become:

$$w_{it} = h_i^{-1}\left[q_{it}\frac{1-ad_i\theta_i}{1-a\mu_i\theta_i} + \frac{\varphi_i}{1-\theta_i}\left(\frac{1-ad_i}{1-a\mu_i} - \frac{1-ad_i\theta_i}{1-a\mu_i\theta_i}\right)\right], i = 1, \ldots, n \tag{11}$$

where $\mu_i = 1 - h_i^{-1}$, $d_i = 1 - \delta_i$ and $\alpha = 1/(1+r)$, *r* is a constant discount rate.

With the simplification that $\varphi_i = 0$, expression (11) becomes:

$$w_{it} = \frac{1}{h_i}\left\{\frac{1-ad_i\theta_i}{1-a\mu_i\theta_i}\right\} q_{it}$$

Specifying the price expectations processes reveals that the user costs are unobservable because of the technical efficiency parameters h_i and the expectations parameters φ_i, θ_i. Once the concavity and user cost elements are incorporated into the demand equations for efficiency adjusted inputs, the outcome is a set of equations that are very nonlinear in coefficients. With the cost function and price expectations processes specified, the estimation model consists of the observed demand per unit of output equations (with the user costs defined), and the AR(1) price expectation equations: $q_{it+1} = \theta_i q_{it} + e^q_{it+1}$. Error terms are assumed to be identically and independently distributed over time with zero expected value (see Nadiri and Prucha (1989) for a justification of the additive errors in the factor demand equations).

One concern of the project is to investigate the effects of increases in end-user prices of fuel and electricity (as a result of policies to reduce GHG emissions and increase the penetration of renewable) on factor demands. When the system of factor demand equations is estimated along with the price generating processes one can obtain the elasticities of input demands in order to establish the relationship (complementarity or substitutability) between the inputs under investigation.

The elasticity of demand for efficiency adjusted input i with respect to the user cost of this input, w_{it} evaluated at year *t* is:

$$\varepsilon_{iit}^{zw} = \left[\partial Z_i(\dot{t}) \big/ \partial w_{it} \right] \left(w_{it} \big/ z_{it}^* \right), i = 1,2, \dots, n$$

where $Z_i(\dot{t})$ is the demand function and z_{it}^* is the value of this function in year *t*.

The elasticity (long run elasticities) of demand for efficiency adjusted input i, with respect to the user cost of input *j*, namely w_{jt} (j ≠ i) and evaluated in year *t* is:

$$\varepsilon_{ijt}^{zw} = \left[\partial Z_i(\dot{t}) \big/ \partial w_{jt} \right] \left(w_{jt} \big/ z_{it}^* \right), i, j = 1,2, \dots, n; j \neq i$$

The short run elasticities are given by:

$$\varepsilon_{ijt}^{zw} = \left[\partial v_i \big/ \partial w_j \right] \left(w_j \big/ v_i \right) = h_i^{-1} \left[\partial z_i \big/ \partial w_j \right] \left(w_j \big/ v_i \right) \left(z_j \big/ v_i \right) = h_i^{-1} \epsilon_{ij}{}^{zw} \left(z_j \big/ v_i \right) \quad (12)$$

3. EMPIRICAL RESULTS

The equation sets mentioned in Section 2 are jointly estimated by the Nonlinear Seemingly Unrelated Regression estimator. There are five factors of production (labor, capital, raw materials, electricity and fuels), and thus our system consists of ten equations – five input intensity equations and five equations relating to price expectations.

The results from the system estimation are presented in Table 1, along with appropriate diagnostic tests (see Bernstein et al. 2004). The hypotheses of first and second order serial correlation and white heteroskedasticity and ARCH are all rejected. Further tests reveal that the hypothesis of constant returns to scale is rejected and that the time trend is statistically significant. Concavity has been imposed during the estimation, using the Wiley, Schmidt and Bramble (1973) technique. Dummies are also included for each industry in all the equations. An χ^2 test was performed which suggests that the dummy variables are jointly significant and should therefore be included in the system. In addition the constant term φ_i of the price expectations equations are not jointly significant and are set equal to zero.

The estimates of the efficiency parameters suggest that technical efficiency levels increase with factor additions. Moreover, as the case of $h_i = 1$ implies that efficiency does not change, the rate of efficiency growth for the ith input can be expressed as $h_i - 1$. Significant adjustment costs would occur if efficiency parameters were below 1, implying negative rates of efficiency growth. These rates, for our data, are estimated to be 0.13% for raw materials, 2.04% for electricity, 6.52% for capital, 4.71% for labor and 46.6% for fuels.

Table 1: Parameter Estimates

Parameter	Estimate	St. Error	Parameter	Estimate	St. Error
β_{LL}	-0.343	0.303	$\boldsymbol{\beta_{LT}}$	-0.019	0.008
β_{LK}	-0.766	0.331	$\boldsymbol{\beta_{KT}}$	-0.048	0.013
β_{LF}	-0.990	6.339	$\boldsymbol{\beta_{FT}}$	0.036	0.233
β_{LE}	-0.124	0.086	$\boldsymbol{\beta_{ET}}$	0.009	0.005
β_{LM}	0.228	0.099	$\boldsymbol{\beta_{MT}}$	-0.0006	0.005
β_{KK}	-1.708	0.181	$\boldsymbol{h_L^{-1}}$	0.173	0.035
β_{KF}	-2.208	14.09	$\boldsymbol{h_K^{-1}}$	0.133	0.003
β_{KE}	-0.277	0.148	$\boldsymbol{h_F^{-1}}$	0.022	0.035
β_{KM}	0.509	0.025	$\boldsymbol{h_E^{-1}}$	0.329	0.022
β_{FF}	-2.855	36.46	$\boldsymbol{h_M^{-1}}$	0.883	0.025
β_{FE}	-0.355	2.293	$\boldsymbol{\theta_L}$	0.175	0.066
β_{FM}	0.659	4.205	$\boldsymbol{\theta_K}$	0.943	0.005
β_{EE}	-0.045	0.048	$\boldsymbol{\theta_F}$	0.353	0.051
β_{EM}	0.083	0.044	$\boldsymbol{\theta_E}$	0.233	0.053
β_{MM}	-0.152	0.017	$\boldsymbol{\theta_M}$	0.076	0.063
β_L	0.039	0.131			
β_K	0.982	0.356			
β_F	-1.513	9.744			
β_E	-0.248	0.140			
β_M	0.594	0.045			

Equation	St. Error	R^2
Labor	0.009	0.997
Capital	0.022	0.996
Fuel	0.025	0.927
Electricity	0.011	0.966
Materials	0.168	0.828
Log of LF	2073.78	

HYPOTHESIS TESTS

	Test statistic	$X^2_{0.05}$
1st order serial correlation	LM=10.41	124.34
2nd order s. correlation	LM=21.51	255.26
Heteroskedasticity-ARCH(2)	LM=28.02	31.41
Heteroskedasticity (White)	LM=12.65	31.41
Constant Returns to scale	LR=0.24	14.07
Significance of time trend	LR=189.7	14.07

The estimated rates of efficiency growth for raw materials are the lowest, whereas efficiency growth rates for capital accumulation and labor indicate that the new capital and labor are more efficient than their current levels. Efficiency gains arise from new electricity inputs as well. The efficiency gains from new electricity inputs are not offset by the efficiency-eroding adjustment costs.

These estimation results indicate that technical efficiency levels rise with new fuel inputs used in production. From the estimation we observe that fuels have the largest rate of efficiency growth among all inputs. Therefore, the efficiency gains from fuel input improvements or new fuel inputs are not offset by the reductions in efficiency arising from their adjustment costs. The large efficiency effect of fuels relative to the other inputs implies that every year the contribution of this input in production increased not only because of net editions, but also because those net additions had a higher marginal product than fuel inputs already in use.

To study the substitutability or complementary of inputs the price elasticities of the inputs are calculated for the short and the long run and they are presented in Table 2.

A positive elasticity implies that the two inputs are substitutes, while a negative one points to a complementary relationship. From the estimation results, the scale effect and the technical change effect can be calculated. On average the scale effect is equal to 1.05. The technical change effect is negative and equal to -0.0004. This means that improvements in technology reduce cost.

Table 2: Elasticities (Average over the sample)

Short Run Elasticities					
	Quantity				
Price	Labor	Capital	Materials	Electricity	Fuels
Labor	-0.00554	0.00657	0.00346	-0.01799	-0.00329
Capital	0.00359	-0.05214	0.04615	0.03937	-0.0657
Materials	0.0053	0.38057	-0.38587	-0.09183	0.53598
Electricity	-0.00033	-0.00691	0.00691	-0.01283	-0.00987
Fuels	-0.00001	-0.00124	0.00109	-0.00098	-0.00143
Long Run Elasticities					
	Labor	Capital	Materials	Electricity	Fuels
Labor	-0.0318	0.0274	0.0059	-0.0012	-0.0002
Capital	0.0385	-0.3927	0.4308	-0.0212	-0.058
Materials	0.0204	0.3478	-0.4379	0.0211	0.0509
Electricity	-0.1044	-0.296	-0.104	-0.0398	-0.046
Fuels	-0.0197	-0.494	0.6079	-0.0302	-0.0672

As expected, the own effect of each input price is negative. Therefore each input price affects its own demand negatively. The total average elasticities shown in Table 2 suggest that labor and electricity and labor and fuels are complements, while labor and materials and labor and capital are substitutes. Capital and material also appear to be substitutes, while the relationship between capital and electricity as well as capital and fuels is complementary. Materials and electricity, as well as materials and fuels appear to be substitutes. Finally, electricity and fuels are complements in the production process.

In summary, the results demonstrate that in most sectors, as well as the total economy, both electricity and fuels are complements to labor and capital and substitutes for raw materials. There are some exceptions in individual manufacturing subsectors, where energy and labor turn out to be substitutes, which indicate that higher energy prices may not be detrimental to employment in these cases.

Based on that, our results indicate that when examining the effect of policies which tend to increase energy prices, one should examine each economic sector (and perhaps its subsectors) separately in order to derive policy-relevant conclusions since the effect of a change in the price of electricity and fuels appears to vary considerably across sectors. Overall, our results for Cyprus are in line with those of the earlier literature that was mentioned in the introductory section. Note, however, that previous studies estimated higher elasticities; this difference is expected because our model distinguishes between short run and long run behavior and also accounts for adjustment costs, which tend to reduce the effect of energy on other factor demands.

4. SIMULATIONS

Assuming a change in prices one can calculate the effect of price changes on total production cost (expressed as percentage change). Since the specification in equation (7) of this function is second order, with time-invariant second order parameters, the cost difference between periods s and t, defined as $c_t - c_s$, consists only of first order terms (see Diewert (1981), Denny and Fuss (1983)). Thus,

$$c_t - c_s = 0.5\sum_{i=1}^{n}\left(\frac{\partial c_t}{\partial \omega_{it}} + \frac{\partial c_s}{\partial \omega_{is}}\right)(\omega_{it} - \omega_{is}) + 0.5\left(\frac{\partial c_t}{\partial y_t} + \frac{\partial c_s}{\partial y_s}\right)(y_t - y_s)$$
$$+ 0.5\left(\frac{\partial c_t}{\partial t} + \frac{\partial c_s}{\partial s}\right)(t - s) \qquad (13)$$

Since $\frac{\partial c_t}{\partial w_{it}} = z_i$ from (5), define the mean value as $z_{im}^* = 0.5(z_{it}^* + z_{is}^*)$, (subscript m denotes the mean value of a variable between period t and s) $w_{im} = 0.5(w_{it} + w_{is})$,

$(\frac{\partial c}{\partial y})_m = 0.5(\frac{\partial c_t}{\partial y_t} + \frac{\partial c_s}{\partial y_s})$, $(\frac{\partial c}{\partial t})_m = (\frac{\partial c_t}{\partial t} + \frac{\partial c_s}{\partial t})$ and divide (13) by $c_m = 0.5(c_t + c_s)$ in terms of growth rates becomes

$$\widehat{c_t} = \sum_{i=1}^{n} \frac{z_{im}\omega_{im}}{c_m} \widehat{\omega_{it}} + \left(\frac{\partial c}{\partial y}\right)_m \frac{y_m}{c_m} \widehat{y_t} + \left(\frac{\partial c}{\partial t}\right)_m \frac{(t-s)}{c_m} \qquad (14)$$

where $\hat{c}_t = (c_t - c_s)/c_m$, $\widehat{w}_{it} = (w_{it} - w_{is})/w_{im}$, $\hat{y}_t = (y_t - y_s)/y_m$ are the growth rates of cost input prices and output.

Alternatively in discrete terms the growth rate is:

$$\widehat{c_t} = 0.5 \sum_{i=1}^{n} \left(s_{it} \frac{c_t}{\omega_{it}} + s_{is} \frac{c_s}{\omega_{is}} \right) \frac{\omega_{im}}{c_m} \widehat{\omega_{it}} + 0.5(\rho_t^{-1} \frac{c_t}{y_t} + \rho_s^{-1} \frac{c_s}{y_s}) \frac{y_m}{c_m} \widehat{y_t} + 0.5(\varepsilon_{ct} c_t + \varepsilon_{cs} c_s) \frac{(t-s)}{c_m} \qquad (15)$$

where s_i the shares, ρ the returns to scale and ε exogenous technical change.

Using specification (15), along with the price expectation equations (9) and (11) and their estimated coefficients, one can simulate the effects of price increases on total production costs. In our case it is more meaningful to simulate the effect on production costs under the assumption of a combined increase in prices of both electricity and other fuels. The variables per sector used for the simulations are presented in Table 3.

Table 3: Variables used in simulations (averages per sector)

Sectors	Shares							
	s_{iL}	s_{iK}	s_{iM}	s_{iE}	s_{iF}	ρ_t^{-1}	ε_{ct}	ρ_t
Agriculture, hunting and Forestry	0.426	0.152	0.411	0.007	0.008	0.988	-0.010	1.012
Mining and quarrying	0.286	0.261	0.332	0.043	0.078	0.821	-0.015	1.217
Electricity, gas and water	0.173	0.350	0.454	0.015	0.008	0.958	-0.006	1.044
Construction	0.296	0.226	0.466	0.003	0.008	0.988	-0.009	1.012
Wholesale, retail trade	0.162	0.492	0.312	0.014	0.020	0.939	-0.218	1.065
Hotels and restaurants	0.175	0.273	0.517	0.025	0.010	0.980	-0.006	1.021
Transport and communication	0.312	0.317	0.341	0.011	0.019	0.980	-0.009	1.021
Manufacturing	0.203	0.203	0.559	0.012	0.022	0.994	-0.006	1.006

Zachariadis and Shoukri (2011) have conducted a preliminary review of the direct effects of the EU energy and climate package on energy prices in Cyprus, which was based on consultation with public authorities and local experts. The simulations presented here have used the assumed price increases that were included in that report, which are also summarized in Table 4.

Table 4: Assumed end-user price increases as a result of the implementation of the EU energy and climate package in Cyprus

	Year 2013		Year 2020	
Scenarios	Baseline	High impacts	Baseline	High impacts
Change in price of:				
electricity	4.7%	10.0%	12.6%	20.0%
automotive petrol	0.0%	3.0%	6.0%	10.0%
automotive diesel	3.0%	6.0%	8.0%	15.0%
other fuels	0.0%	0.0%	0.0%	0.0%

Source: Zachariadis and Shoukri (2011).

In this project, three main scenarios have been simulated: A benchmark or "historical trend" scenario, which assumes that the prices of inputs, output and technical change continue to grow with the average growth rate (per sector) over the sample; and a "baseline" scenario in which electricity and fuel prices increase according to the EU package (see Table 5) and the rest of variables grow as in the benchmark scenario. This baseline scenario assumes that energy prices in Cyprus will grow up to the year 2020 as expected by the EU energy and climate package, without any unexpected events (such as sharp increases in compliance costs, drastic changes in carbon permit prices or shortages in the supply of biofuels) that would further raise prices. And a 'high impacts' case, assuming that international energy and environmental agreements or regulations may cause energy prices to grow more strongly than initially expected (e.g. due to an increase in oil and gas prices or in the prices of CO_2 emission allowances, or because of higher biofuel prices as a result of rising global demand for biofuels).

Table 5: Assumed changes in prices (%)

	Baseline		High impact	
Year	Electricity	Fuels	Electricity	Fuels
2013	5	2	10	4.5
2014	6	2.6	11.3	5.4
2015	7	3.1	12.7	6.3
2016	8.5	3.9	14.1	7.3
2017	9.5	4.5	15.5	8.4
2018	10.5	5.1	17	9.6
2019	11.5	5.9	18.5	10.7
2020	13	7	20	13

The results presented here will be for the baseline scenario, the high impact scenario and their differences with the historical trend (benchmark) scenario. The difference will show us the extra cost from the EU package measures, the two above scenarios, in percentage and million of 2010 Euros. In our case it is more meaningful to simulate the effect on production costs under the assumption of a combined increase in prices of both electricity and other fuels. All the results presented below are based on the combined increase of electricity and fuel prices. Table 6 presents the extra cost (percentage change) from the two scenarios in 2020 in various economic sectors.

Table 6: Change in production costs (%) by economic sector of Cyprus in the year 2020, for a combined increase in electricity and fuel prices.

	Baseline scenario	*High Impacts scenario*
Electricity price increase in 2020:	*12.6%*	*20.0%*
Fuel price increase in 2020:	*7.0%*	*13.0%*
Agriculture, hunting and forestry	0.1334	0.1956
Mining and quarrying	1.0407	1.7160
Electricity, Gas and Water	0.2205	0.3385
Construction	0.095	0.1574
Wholesale, Retail Trade	0.2975	0.4818
Hotels and Restaurants	0.3786	0.5794
Transport and Communication	0.3043	0.4985
Manufacturing	0.2842	0.4109
Food, Beverages and Tobacco	0.1930	0.2600
Chemicals, Petroleum, Rubber, Plastic	0.1099	0.1971
Non-Metallic Mineral Products	0.2272	0.3700
Metal products, Machinery, Equipment	0.1380	0.2312
Other manufacturing industries	0.1761	0.2575
Total Average	0.3442	0.5473

Economy-wide production costs are expected to rise due to the measures taken by each country, reaching 0.34% in the baseline scenario and 0.55% in the high impacts scenario. Mining and quarrying and hotels and restaurants are the most vulnerable industries due to the increase of both electricity prices and fuel prices, whereas the chemicals and metal products industries are expected to be the least affected in this case. For some sectors the production cost increase is mainly due to rising electricity prices, whereas higher prices of automotive fuels make a greater difference to sectors 'transport and communications' and 'construction' – two sectors that are highly dependent on fuel use.

Assuming that energy prices will grow gradually between years 2013 and 2020 in line with the information of Table 5 we have assessed the annual evolution of production cost increases during this 8-year period. These are illustrated in Table 7. Costs increase mildly in the first years, because the Cypriot power generation sector can still acquire a substantial portion of free CO_2 emission allowances and automotive biofuel mandates are not stringent during the first years; this leads to a smooth increase in end-user prices of fuel and electricity. Then prices grow more strongly and hence production cost rises by 2020 up to the levels shown in the last row of Table 6. This is the extra cost from implementation of the measures suggested by the EU.

Table 7: Annual increases in economy-wide production costs (%) for a combined increase in electricity and fuel prices in the period 2013-2020

Year	*Baseline scenario*	*High Impacts scenario*
2013	0.1225	0.2432
2014	0.1505	0.2803
2015	0.1758	0.3184
2016	0.2147	0.3580
2017	0.2417	0.3991
2018	0.2685	0.4430
2019	0.2989	0.4845
2020	0.3442	0.5473

The results for the baseline scenario and the difference between the baseline and the historical scenario (which show the extra cost from the EU measures) are presented in Tables 8 and 9. These tables show the percentage change in cost by sector for the years 2013-2020.

Table 8: Percentage change in Cost by sector

	Baseline Scenario							
Sectors	2013	2014	2015	2016	2017	2018	2019	2020
Agriculture, hunting and forestry	5.965	5.976	5.986	6.001	6.011	6.022	6.033	6.050
Mining and quarrying	6.587	6.672	6.750	6.868	6.952	7.035	7.131	7.268
Electricity, gas and water	9.896	9.914	9.930	9.956	9.972	9.989	10.007	10.032
Construction	4.192	4.199	4.206	4.217	4.225	4.232	4.241	4.254
Wholesale, retail trade	4.089	4.113	4.135	4.169	4.193	4.216	4.243	4.280
Hotels and restaurands	4.933	4.962	4.990	5.032	5.061	5.089	5.118	5.162
Transport and communication	4.468	4.493	4.515	4.550	4.574	4.599	4.626	4.666
Manufacturing	4.566	4.589	4.608	4.638	4.659	4.681	4.705	4.756
Total	5.587	5.615	5.640	5.679	5.706	5.733	5.763	5.808

Table 9: Percentage change in Cost by sector

	Difference between baseline scenario and historical							
Sectors	2013	2014	2015	2016	2017	2018	2019	2020
Agriculture, hunting and forestry	0.0480	0.0595	0.0688	0.0840	0.0946	0.1050	0.1167	0.1334
Mining and quarrying	0.3597	0.4452	0.5226	0.6413	0.7246	0.8074	0.9042	1.0407
Electricity, gas and water	0.0847	0.1021	0.1189	0.1441	0.1609	0.1776	0.1951	0.2205
Construction	0.0317	0.0395	0.0465	0.0572	0.0648	0.0724	0.0814	0.0941
Wholesale, retail trade	0.1058	0.1300	0.1522	0.1862	0.2097	0.2331	0.2597	0.2975
Hotels and restaurands	0.1496	0.1789	0.2071	0.2493	0.2777	0.3059	0.3355	0.3786
Transport and communication	0.1063	0.1312	0.1539	0.1886	0.2129	0.2369	0.2649	0.3043
Manufacturing	0.0944	0.1175	0.1363	0.1669	0.1882	0.2093	0.2336	0.2842
Total	0.1225	0.1505	0.1758	0.2147	0.2417	0.2685	0.2989	0.3442

We observe that production costs may growth by 5.8% over the entire economy in 2020 as a result of an increase in the prices of all inputs and output. Based on Table 9, 0.34% over the entire economy in the year 2020 can be attributed to higher electricity and fuel prices due to the measures taken by the country.

This percentage increase in cost is, on average, 0.12% in 2013 and increases gradually over the years until 2020. Table 5 demonstrates also which sectors will be most affected by the increase in the prices of electricity and fuels due to the EU energy and climate package. The two sectors most vulnerable to these extra price changes will be the energy intensive mining and quarrying sector as well as hotels and restaurants. Looking within individual sub-sectors of the manufacturing sector, the cement industry is also expected to experience considerable cost increases. The latter two sectors, which are related to tourism and cement exports respectively, are exposed to international competition, and therefore this finding indicates that their competitiveness may be somewhat endangered due to the increased costs associated with the implementation of energy and climate policies.

Similarly, for the high impact scenario the results are presented in tables 10 and 11. Now the percentage changes appear to be higher, and so is the extra cost with respect to these measures.

Table 10:Percentage change in cost by sector

	high impact scenario							
Sectors	2013	2014	2015	2016	2017	2018	2019	2020
Agriculture, hunting and forestry	5.9941	6.0086	6.0236	6.0391	6.0551	6.0722	6.0885	6.1124
Mining and quarrying	6.9709	7.0870	7.2056	7.3302	7.4606	7.6002	7.7311	7.9432
Electricity, gas and water	9.9795	10.0017	10.0249	10.0483	10.0719	10.0969	10.1211	10.1500
Construction	4.2262	4.2369	4.2478	4.2594	4.2715	4.2846	4.2967	4.3174
Wholesale, retail trade	4.1991	4.2314	4.2647	4.2992	4.3351	4.3734	4.4096	4.4646
Hotels and restaurands	5.0722	5.1097	5.1489	5.1886	5.2285	5.2710	5.3121	5.3624
Transport and communication	4.5804	4.6140	4.6485	4.6845	4.7221	4.7623	4.8002	4.8601
Manufacturing	4.6371	4.6667	4.6971	4.7289	4.7619	4.7972	4.8305	4.8822
Total	5.7074	5.7445	5.7826	5.8223	5.8634	5.9072	5.9487	6.0115

Table 11:Percentage change in cost by sector

	Difference between high impact and historical							
Sectors	2013	2014	2015	2016	2017	2018	2019	2020
Agriculture, hunting and forestry	0.0773	0.0918	0.1068	0.1223	0.1384	0.1555	0.1717	0.1956
Mining and quarrying	0.7438	0.8599	0.9785	1.1031	1.2335	1.3731	1.5040	1.7160
Electricity, gas and water	0.1680	0.1901	0.2134	0.2368	0.2603	0.2853	0.3096	0.3385
Construction	0.0663	0.0770	0.0879	0.0994	0.1116	0.1246	0.1368	0.1574
Wholesale, retail trade	0.2162	0.2486	0.2818	0.3164	0.3522	0.3905	0.4267	0.4818
Hotels and restaurands	0.2892	0.3267	0.3660	0.4056	0.4456	0.4881	0.5292	0.5794
Transport and communication	0.2189	0.2525	0.2869	0.3230	0.3606	0.4008	0.4386	0.4985
Manufacturing	0.1658	0.1954	0.2259	0.2576	0.2906	0.3259	0.3592	0.4109
Total	0.2432	0.2803	0.3184	0.3580	0.3991	0.4430	0.4845	0.5473

In actual terms, total production costs are assessed to rise by 413.4 million Euros 2010 in year 2020 in the historical trend scenario and by 436.8 million Euros in 2010 prices in the baseline scenario. The manufacturing sector, the hotels and restaurants and the trade sector are projected to incur two thirds of these cost increases. Tables 12 and 13 present the increase in cost with the baseline scenario and the difference in the actual cost change between the two scenarios respectively.

Table 12: increase in Cost by sector, millions of 2010 Euros								
	Baseline Scenario							
Sectors	2013	2014	2015	2016	2017	2018	2019	2020
Agriculture, hunting and forestry	39.21	39.29	39.35	39.45	39.52	39.59	39.67	39.78
Mining and quarrying	3.61	3.66	3.70	3.77	3.81	3.86	3.91	3.99
Electricity, gas and water	31.29	31.35	31.40	31.48	31.53	31.59	31.64	31.72
Construction	56.66	56.77	56.86	57.01	57.11	57.21	57.34	57.51
Wholesale, retail trade	61.86	62.23	62.56	63.08	63.43	63.79	64.19	64.76
Hotels and restaurands	61.48	61.84	62.19	62.72	63.07	63.42	63.79	64.33
Transport and communication	50.41	50.70	50.95	51.34	51.62	51.89	52.20	52.65
Manufacturing	117.21	117.80	118.29	119.07	119.62	120.16	120.78	122.08
Total	421.74	423.63	425.31	427.91	429.72	431.50	433.52	436.81

Table 13: Increase in Cost by sector, in milllions of 2010 Euros								
	Difference between baseline scenario and historical							
Sectors	2013	2014	2015	2016	2017	2018	2019	2020
Agriculture, hunting and forestry	0.316	0.391	0.453	0.553	0.622	0.690	0.767	0.877
Mining and quarrying	0.197	0.244	0.287	0.352	0.397	0.443	0.496	0.571
Electricity, gas and water	0.268	0.323	0.376	0.456	0.509	0.562	0.617	0.697
Construction	0.429	0.534	0.628	0.774	0.876	0.979	1.101	1.272
Wholesale, retail trade	1.601	1.967	2.303	2.817	3.173	3.526	3.929	4.501
Hotels and restaurands	1.865	2.230	2.581	3.107	3.461	3.812	4.182	4.719
Transport and communication	1.199	1.480	1.736	2.128	2.402	2.674	2.989	3.434
Manufacturing	2.424	3.016	3.499	4.284	4.831	5.374	5.997	7.297
Total	8.30	10.19	11.86	14.47	16.27	18.06	20.08	23.37

From Table 13 we observe that the actual change in cost, due to the implementation of the EU policies will reach 23.4 million (in Euros 2010), in 2020 for the total economy. The cost difference between the two scenarios starts at 8.3 million Euros'2010 in 2013 and as the prices of electricity and fuels grow over the years the actual cost difference grows as well. Manufacturing, hotels and restaurants and the trade sector will face the highest cost increase due to the implementation of the EU energy and climate package; their actual costs are projected to increase by 7.3, 4.7 and 4.5 million Euros'2010 respectively.

The results for the high impact scenario are similar. The percentage changes and the actual cost changes are higher. Specifically, the actual extra change in costs (from the high impact scenario), due to the EU package is 36.1 millions in Euros 2010. These results are presented in Tables 14 and 15.

Table 14: Increase in cost by sectors, in millions of 2010 Euros

	high impact scenario							
Sectors	2013	2014	2015	2016	2017	2018	2019	2020
Agriculture, hunting and forestry	39.41	39.50	39.60	39.70	39.81	39.92	40.03	40.18
Mining and quarrying	3.82	3.89	3.95	4.02	4.09	4.17	4.24	4.36
Electricity, gas and water	31.56	31.63	31.70	31.77	31.85	31.93	32.00	32.10
Construction	57.13	57.28	57.42	57.58	57.74	57.92	58.08	58.36
Wholesale, retail trade	63.53	64.02	64.52	65.05	65.59	66.17	66.72	67.55
Hotels and restaurands	63.22	63.68	64.17	64.67	65.16	65.69	66.21	66.83
Transport and communication	51.68	52.06	52.45	52.86	53.28	53.74	54.16	54.84
Manufacturing	119.04	119.80	120.58	121.40	122.25	123.15	124.01	125.33
Total	429.39	431.86	434.41	437.05	439.78	442.69	445.45	449.55

Table 15: Increase in cost by sectors, in millions of 2010 Euros

	Difference between high impact and historical							
Sectors	2013	2014	2015	2016	2017	2018	2019	2020
Agriculture, hunting and forestry	0.508	0.604	0.702	0.804	0.910	1.022	1.129	1.286
Mining and quarrying	0.408	0.472	0.537	0.605	0.677	0.753	0.825	0.941
Electricity, gas and water	0.531	0.601	0.675	0.749	0.823	0.902	0.979	1.070
Construction	0.896	1.041	1.188	1.344	1.509	1.685	1.849	2.128
Wholesale, retail trade	3.272	3.761	4.264	4.787	5.329	5.909	6.456	7.289
Hotels and restaurands	3.605	4.072	4.561	5.055	5.553	6.083	6.595	7.221
Transport and communication	2.469	2.849	3.237	3.644	4.068	4.522	4.949	5.625
Manufacturing	4.256	5.017	5.798	6.613	7.461	8.367	9.222	10.548
Total	15.945	18.416	20.963	23.602	26.330	29.244	32.004	36.109

Using the results, along with the total output of the economy, we calculate the unit cost per sector. Per unit of output, the cost increases are very small and close to zero. This unit cost variable shows the cost that goes to the consumers, and based on our results it suggests that consumers are not going to be very affected by these extra increases. Specifically, small unit costs suggest that the prices of the goods will not be affected in the long run. The results are presented in Table 16.

Table 16:Increase in unit cost of production by sectors, in millions of 2010 Euros								
	Difference between baseline with historical							
Sectors	2013	2014	2015	2016	2017	2018	2019	2020
Agriculture, hunting and forestry	0.001	0.001	0.001	0.002	0.002	0.002	0.002	0.003
Mining and quarrying	0.009	0.012	0.014	0.017	0.019	0.021	0.024	0.027
Electricity, gas and water	0.003	0.003	0.004	0.004	0.005	0.005	0.006	0.007
Construction	0.001	0.002	0.002	0.002	0.003	0.003	0.003	0.004
Wholesale, retail trade	0.004	0.004	0.005	0.006	0.007	0.008	0.009	0.010
Hotels and restaurands	0.006	0.007	0.008	0.010	0.011	0.012	0.013	0.015
Transport and communication	0.005	0.006	0.007	0.009	0.010	0.012	0.013	0.015
Manufacturing	0.002	0.003	0.003	0.004	0.004	0.005	0.005	0.007
Total	0.031	0.038	0.045	0.055	0.061	0.068	0.076	0.087
	Difference between high impact and historical							
Sectors	2013	2014	2015	2016	2017	2018	2019	2020
Agriculture, hunting and forestry	0.002	0.002	0.002	0.003	0.003	0.003	0.004	0.004
Mining and quarrying	0.019	0.022	0.026	0.029	0.032	0.036	0.039	0.045
Electricity, gas and water	0.005	0.006	0.006	0.007	0.008	0.009	0.009	0.010
Construction	0.003	0.003	0.004	0.004	0.005	0.005	0.006	0.006
Wholesale, retail trade	0.007	0.009	0.010	0.011	0.012	0.013	0.015	0.017
Hotels and restaurands	0.011	0.013	0.014	0.016	0.017	0.019	0.021	0.023
Transport and communication	0.011	0.012	0.014	0.016	0.018	0.019	0.021	0.024
Manufacturing	0.004	0.005	0.005	0.006	0.007	0.008	0.008	0.010
Total	0.062	0.072	0.081	0.091	0.102	0.113	0.123	0.139

Although our work focuses on the production sector only and hence does not address the costs of the energy and climate package on households, the extra increase in total production costs of 23 million Euros'2010 shown in Table 6 constitutes about 0.12% of the expected GDP of Cyprus in year 2020 (around 20 billion Euros'2010). In the "high impact" scenario this extra increase will constitute 0.18% of the expected GDP of 2020. Although not directly comparable, this figure is higher than the ‘energy system costs’ computed in the European Commission's impact assessment (less than 0.1% of GDP). And when the interaction between the production and the consumption side is taken into account and the welfare effects on households are also accounted for, the difference between these two cost estimates will increase. A major reason for the difference between the European Commission's and our calculations lies probably in the assumptions embedded in the Commission's modeling work that a) the policy targets can be achieved with low implementation costs, and b) that overall compliance costs will largely be compensated by the adoption of energy-saving equipment that reduces variable energy costs over the years. Conversely, our modeling framework allows not only for efficiency gains through the accelerated replacement of old capital with new more efficient one, but it also allows for the existence of adjustment costs associated with new capital formation, which in turn tend to discourage new investments in energy saving equipment. Hence one can state with confidence that the costs associated with the adoption of the EU energy and climate package in Cyprus will be higher than those initially projected by the European Commission.

5. CONCLUSIONS

The European Union's energy and climate policy package, which was legally adopted in early 2009, may have significant effects on the European economy. In the case of Cyprus, it is expected to cause an increase in end-user electricity prices and a less pronounced rise in the retail prices of automotive fuels. In this project we tried to assess the effects of these price increases on the economy of Cyprus. We specified and estimated econometrically a production model with five factors of production (capital, labor, raw materials, electricity and fuels) which embodies rational expectations and dynamic optimization in the presence of efficiency gains and adjustment costs; it is probably the first time that such a dynamic model is employed to explore the effect of energy on the economy. For this purpose we constructed a comprehensive dataset, the most detailed that was possible to compile in view of national data availability. Estimation results are in line with the international literature and with economic theory. The estimated efficiency parameters suggest that technical efficiency levels increase with factor additions. Efficiency growth rates are 0.13% for raw materials, 2.04% for electricity, 6.52% for capital, 4.71% for labor and 46.6% for fuels.

On average, it turns out that energy (both electricity and fuel use) are complements with capital and labor in most cases. Electricity and fuels are complements in the production process. A more detailed analysis reveals a substantial sectoral variation of the relationship between electricity and fuel prices and other input demands. This underlines the need to study the effects of energy-related inputs on the demand of other factors of production on a sectoral basis.

We then carried out simulations of changes in sectoral production costs in Cyprus up to the year 2020 as a result of the assumed energy price increases. We calculated that production costs may grow by 0.34% over the entire economy in the year 2020 as a result of higher electricity and fuel prices due to EU package. In absolute terms, production costs are assessed to rise by 436.8 million Euros'2010 in year 2020, out of which 23.4 millions are attributed to the extra increases in the prices of electricity and fuels associated with the implementation of energy and climate policies. Similarly for the high impact scenario the production cost may grow by 0.55% due to the EU package. In absolute terms, the increase in costs for the high impact scenario is assessed to be 450 million of 2010 Euros of which 36.1 are due to the implementation of the policies.

The manufacturing sector, hotels and restaurants and the trade sector are projected to incur two thirds of these cost increases. The largest percentage increases in costs occur in the sectors mining and quarrying, hotels and restaurants and transport and communications. The two sectors (which are related to tourism and cement exports respectively) are exposed to international competition, and this finding indicates that their competitiveness may be endangered due to the increased costs associated with the implementation of energy and climate policies. The calculation of the unit costs (cost per output) suggest that consumers are not going to be affected by these price increases, since the unit costs show the costs that goes to the prices of goods and therefore affect the consumers, and here this values are small.

Although not directly comparable, our calculations indicate that the costs associated with the adoption of the EU energy and climate package in Cyprus will be higher than those initially projected by the European Commission. This underlines the importance of using an appropriate modelling framework such as the one used in this project in order to arrive at realistic policy conclusions.

REFERENCES

Apostolakis, B.E. (1990), “Energy-capital substitutability/complementarity: the dichotomy”, Energy Economics, 12**:** 48–58.

Berndt, E. R. (1991), “Energy use, technical progress and productivity growth: a survey of economic issues”, The Journal of Productivity Analysis 2: 67-83.

Berndt, E.R. and Hesse, D.M. (1986), “Measuring and Assessing Capacity Utilization in the Manufacturing Sectors of Nine OECD Countries”, European Economic Review, 30: 961–989.

Berndt, E.R. and Wood, D.O. (1979), “Engineering and econometric interpretations of energy-capital complementarity”, American Economic Review, 69:342–354.

Bernstein, J., Mamuneas T.P. and Pashardes, P. (2004), "Technical Efficiency and U.S. Manufacturing Productivity Growth", Review of Economics and Statistics, 86(1): 402-412.

Böhringer, C., Rutherford, T.F. and Tol, R.S.J. (2009), "The EU 20/20/2020 Targets: An overview of the EMF22 assessment", Energy Economics 31 (Supplement 2): 268–273.

Capros, P., Mantzos, L., Parousos, L., Tasios, N., Klaassen, G. and van Ierland, T. (2011), "Analysis of the EU policy package on climate change and renewables", Energy Policy 39:1476–1485

Frondel, M. and Schmidt, C.M. (2002), "The capital-energy controversy: an artifact of cost shares?", The Energy Journal, 23:53–79.

Jorgenson, D.W (1984), "The Role of Energy in Productivity Growth", American Economic Review, 74(2): 26-30.

Judson, R.A., Schmalensee, R. and Stoker, T.M. (1999), "Economic development and the structure of demand for commercial energy", The Energy Journal, 20(2): 29-57.

Koetse, M.J., de Groot, H.L.F. and Florax, R.J.G.M. (2008), "Capital-energy substitution and shifts in factor demand: a meta-analysis", Energy Economics, 30:2236–2251.

Morrison, C.J. (1993), "Energy and Capital: Further Exploration of E-K Interactions and Economic Performance", The Energy Journal, 14(1): 217-243.

Stern, D.I. (2011), "The role of energy in economic growth", Annals of the New York Academy of Sciences 1219:26-51.

Zachariadis, T. and Shoukri, E. (2011), "Direct Effects from the Implementation of the EU Energy and Climate Package on Cypriot Economic Sectors and Households", Economic Policy Paper No. 02-11, Economics Research Centre, University of Cyprus. http://www.ucy.ac.cy/data/ecorece/DOP02-11.pdf

APPENDIX 1: DATA DESCRIPTION

To estimate the model in line with the methodology described in Section 2, one needs data for the prices and quantities of both the output and the inputs included in the cost function. We obtained relevant data from several publications of the Statistical Service of Cyprus. The data cover the period 1976 to 2008. All prices are expressed in constant Euros of year 2000.

We collected data for each major sector of the Cyprus economy: Agriculture, hunting and Forestry, Mining and Quarrying, Electricity, Gas and Water Supply, Construction, Wholesale and Retail Trade, Hotels and Restaurants, Transport and Communication and Manufacturing. In order to study the manufacturing sector in more detail, and according to data availability, Manufacturing has been split in several subsectors. These are: Food, Beverages and Tobacco, Chemicals, Petroleum, Rubber and Plastic Products, Non-Metallic Mineral Products, Metal products, Machinery and Equipment and Other Manufacturing Industries.

Sectors and subsectors were chosen based on the availability of official fuel and energy related data. Our analysis uses five inputs: labor, capital, electricity, fuels and materials.

The variables used for our analysis are: Gross output in current prices, Price Deflator for Gross output, Value Added in current prices, Value added in constant 2000 prices, Employment, Total hours of employment, Investment in current prices, Investment in 2000 prices, Labor Cost, Cost of Raw materials, Cost of Electricity, Cost of Fuels used in production, prices of petroleum products (gasoline, kerosene, gasoil, light fuel oil, heavy fuel oil and LPG) and Average price of electricity per KWh by category (Domestic, Commercial, Industrial, Agriculture).

For the construction of the output variable, we use the Gross output variable of each sector in current prices (used as the value of output, VY_{it}), along with the price deflator. The quantity of output is calculated as follows:

$$VY_{it} = PY_{it} \times Y_{it} \Rightarrow Y_{it} = \frac{VY_{it}}{PY_{it}}$$

We also obtained the value added in constant and current prices.

For labor, necessary data are the price and quantity of labor. We used employment and hours of employment to construct employment in man-hours: $EMH_{it=}E_{it} * hours$. The cost of labor was used as the compensation of employees (value of labor). Having the value of labor and employment in man-hours the price of labor was obtained, which was transformed in order to be expressed in 2000 prices. Combining labor price and labor value one can derive the quantity of labor in 2000 prices.

Investments, in current and constant prices, were used in order to construct the capital stock. The value of capital was obtained using the value added in current prices and the value of labor. The perpetual inventory method was followed with a constant depreciation rate of 5%, to get the quantity of capital:

$$K_{it} = I_{it} + (1 - \delta)K_{it-1}$$

For the initial value (initial period *t* = 0) of the quantity of capital we use:

$$K_0 = {}^{I_0}\!/_{(\delta + mean(g_Y))}$$

where g_Y is the growth rate of output and δ is the depreciation rate.

For the first variable of interest, fuels, we used the cost of fuels used in production (to approximate the value of fuels in current prices), along with the prices of petroleum products (gasoline, kerosene, gasoil, light fuel oil, heavy fuel oil and LPG) to obtain a weighted average fuel price. The weights were based on the use of each petroleum product in the specific industry. Having the price (expressed in constant terms), the quantity of fuel was calculated.

For electricity we use the cost of electricity (to approximate the value of electricity in current prices), along with the average price of electricity per kWh by category (Domestic, Commercial, Industrial, Agriculture). Transforming the prices to be expressed in constant terms, along with the value of electricity, the quantity of electricity is calculated.

Finally, we derived the price index for materials (again using 2000 as the base year) using the following formula:

$$PM_{it} = \frac{1}{SM_{it}}\left\{PY_{it} - \sum\nolimits_{X=K,L,F,E} PX_{it}\,SX_{it}\right\}$$

where *S* are the output shares of each input, and the cost of raw materials (the value of raw materials in current prices) to obtain the quantity of raw materials.

The total cost was constructed using:

$$C_{it} = \sum\nolimits_{X=K,L,M,E,F} PX_{it}X_{it}$$

To obtain this information we collected data from the official publications of the Statistical Service of Cyprus for various years. These publications comprised National Accounts, Statistical Abstracts, and specialized statistical reports of Labor, Agriculture, Industry, Construction and Housing, Wholesale and Retail Trade, Transport, and Hotels and Restaurants.

APPENDIX 2

AGRICULTURE, HUNTING AND FORESTRY

	QUANTITY				
PRICE	**LABOR**	**CAPITAL**	**MATERIALS**	**ELECTRICITY**	**FUELS**
LABOR	-0.0035	-0.0110	0.0140	-0.0033	-0.0112
CAPITAL	-0.0008	-0.0360	0.0364	-0.0597	-0.0549
MATERIALS	0.0296	0.4082	-0.4315	0.5678	0.5841
ELECTRICITY	-0.0008	-0.0145	0.0154	-0.0188	-0.0206
FUELS	-0.0001	-0.0018	0.0019	-0.0026	-0.0027

MINING, QUARRYING

	QUANTITY				
PRICE	**LABOR**	**CAPITAL**	**MATERIALS**	**ELECTRICITY**	**FUELS**
LABOR	-0.0077	-0.0135	0.0155	-0.0297	-0.0101
CAPITAL	-0.0066	-0.0360	0.0348	0.0495	-0.0675
MATERIALS	0.0980	0.3811	-0.3876	-0.2247	0.6234
ELECTRICITY	-0.0020	-0.0079	0.0087	-0.0014	-0.0125
FUELS	-0.0002	-0.0013	0.0013	0.0011	-0.0023

	QUANTITY				
PRICE	**LABOR**	**CAPITAL**	**MATERIALS**	**ELECTRICITY**	**FUELS**
LABOR	-0.0111	0.0796	-0.0212	0.0164	-0.0279
CAPITAL	0.0237	-0.1497	0.0710	-0.0702	-0.0656
MATERIALS	-0.1141	0.6816	-0.4045	0.4646	0.5391
ELECTRICITY	0.0008	-0.0049	0.0033	-0.0073	-0.0021
FUELS	0.0003	-0.0021	0.0009	-0.0016	-0.0010

CONSTRUCTION

	QUANTITY				
PRICE	**LABOR**	**CAPITAL**	**MATERIALS**	**ELECTRICITY**	**FUELS**
LABOR	-0.0011	0.0052	-0.0030	0.0276	0.0135
CAPITAL	0.0025	-0.0441	0.0388	-0.1148	-0.0783
MATERIALS	-0.0148	0.3365	-0.3055	0.7876	0.5713
ELECTRICITY	0.0003	-0.0068	0.0062	-0.0152	-0.0115
FUELS	0.0001	-0.0013	0.0012	-0.0032	-0.0022

WHOLESALE, RETAIL TRADE

	QUANTITY				
PRICE	**LABOR**	**CAPITAL**	**MATERIALS**	**ELECTRICITY**	**FUELS**
LABOR	-0.0007	-0.0010	-0.0007	-0.1559	-0.0007
CAPITAL	0.0146	0.0265	0.0138	0.3367	0.0153
MATERIALS	-0.0932	-0.1702	-0.0877	-0.1241	-0.0981
ELECTRICITY	-0.0003	-0.0005	-0.0003	-0.0330	-0.0003
FUELS	0.0001	0.0001	0.0001	0.0036	-0.0001

HOTELS AND RESTAURANTS

	QUANTITY				
PRICE	**LABOR**	**CAPITAL**	**MATERIALS**	**ELECTRICITY**	**FUELS**
LABOR	-0.0050	-0.0094	0.0137	0.0005	-0.0072
CAPITAL	-0.0053	-0.0554	0.0578	-0.0867	-0.0850
MATERIALS	0.0622	0.4700	-0.5070	0.6747	0.6908
ELECTRICITY	-0.0002	-0.0063	0.0063	-0.0109	-0.0101
FUELS	-0.0001	-0.0010	0.0009	-0.0018	-0.0016

TRANSPORT AND COMMUNICATION

	QUANTITY				
PRICE	**LABOR**	**CAPITAL**	**MATERIALS**	**ELECTRICITY**	**FUELS**
LABOR	-0.0103	-0.0151	0.0225	-0.0125	-0.0158
CAPITAL	-0.0141	-0.0360	0.0485	-0.0530	-0.0463
MATERIALS	0.1614	0.3621	-0.4990	0.4874	0.4479
ELECTRICITY	-0.0020	-0.0056	0.0078	-0.0084	-0.0072

FUELS	-0.0003	-0.0008	0.0010	-0.0012	-0.0010

MANUFACTURING

	QUANTITY				
PRICE	**LABOR**	**CAPITAL**	**MATERIALS**	**ELECTRICITY**	**FUELS**
LABOR	-0.0047	0.0184	-0.0127	0.0125	0.0321
CAPITAL	0.0150	-0.0870	0.0690	-0.0869	-0.1434
MATERIALS	-0.0873	0.5740	-0.4707	0.6325	0.4355
ELECTRICITY	0.0010	-0.0093	0.0082	-0.0125	-0.0150
FUELS	0.0002	-0.0017	0.0014	-0.0022	-0.0027

SELECTED MANUFACTURING INDUSTRIES

	QUANTITY				
PRICE	**LABOR**	**CAPITAL**	**MATERIALS**	**ELECTRICITY**	**FUELS**
LABOR	-0.00023	-0.00001	-0.00024	-0.02742	0.08281
CAPITAL	0.00002	-0.00011	0.00016	0.00882	-0.02752
MATERIALS	-0.00152	0.00378	-0.00637	-0.37673	0.23108
ELECTRICITY	-0.00017	0.00026	-0.00050	-0.03457	0.09906
FUELS	0.00070	-0.00119	0.00225	0.14784	-0.45613

CHEMICALS, PETROLEUM RUBBER AND PLASTIC

	QUANTITY				
PRICE	**LABOR**	**CAPITAL**	**MATERIALS**	**ELECTRICITY**	**FUELS**
LABOR	-0.00034	0.00096	-0.00044	-0.01291	-0.11735
CAPITAL	0.00010	-0.00065	0.00023	0.00562	0.00715
MATERIALS	-0.00368	0.01619	-0.00632	-0.16973	-0.77313
ELECTRICITY	-0.00029	0.00111	-0.00043	-0.01375	-0.03814
FUELS	0.00133	-0.00489	0.00197	0.05918	-0.27816

NON-METALLIC MINERAL PRODUCTS

	QUANTITY				
PRICE	**LABOR**	**CAPITAL**	**MATERIALS**	**ELECTRICITY**	**FUELS**
LABOR	-0.00023	0.00004	-0.00052	-0.00078	0.00105
CAPITAL	0.00002	-0.00029	0.00035	0.00098	-0.00163
MATERIALS	-0.00174	0.00710	-0.01099	-0.02762	0.04351
ELECTRICITY	-0.00016	0.00043	-0.00075	-0.00183	0.00271
FUELS	0.00075	-0.00192	0.00348	0.00829	-0.01248

METAL PRODUCTS, MACHINERY AND EQUIPMENT

	QUANTITY				
PRICE	**LABOR**	**CAPITAL**	**MATERIALS**	**ELECTRICITY**	**FUELS**
LABOR	-0.00022	0.00085	-0.00059	-0.16654	-0.02747
CAPITAL	0.00006	-0.00068	0.00033	0.05627	-0.02097
MATERIALS	-0.00195	0.01399	-0.00750	-0.45904	0.07462
ELECTRICITY	-0.00016	0.00091	-0.00051	-0.13629	-0.00403
FUELS	0.00071	-0.00386	0.00223	0.54097	-0.04649

OTHER MANUFACTURING INDUSTRIES

	QUANTITY				
PRICE	**LABOR**	**CAPITAL**	**MATERIALS**	**ELECTRICITY**	**FUELS**
LABOR	-0.00030	0.00077	-0.00054	-0.00230	0.01245
CAPITAL	0.00009	-0.00045	0.00026	0.01366	-0.03311
MATERIALS	-0.00258	0.00922	-0.00569	-0.13580	0.44696
ELECTRICITY	-0.00024	0.00071	-0.00044	-0.01183	0.02876
FUELS	0.00096	-0.00280	0.00181	0.02541	-0.09206

TABLE B: LONG RUN ELASTICITIES BY INDUSTRY (AVERAGE OVER TIME)

AGRICULTURE, HUNTING AND FORESTRY

	QUANTITY				
PRICE	**LABOR**	**CAPITAL**	**MATERIALS**	**ELECTRICITY**	**FUELS**
LABOR	-0.0200	-0.0058	0.0336	-0.0025	-0.0052
CAPITAL	-0.0636	-0.2704	0.4623	-0.0442	-0.0859
MATERIALS	0.0807	0.2735	-0.4887	0.0467	0.0897
ELECTRICITY	-0.0189	-0.4489	0.6430	-0.0573	-0.1208
FUELS	-0.0645	-0.4129	0.6616	-0.0627	-0.1242

MINING, QUARRYING

	QUANTITY				
PRICE	**LABOR**	**CAPITAL**	**MATERIALS**	**ELECTRICITY**	**FUELS**
LABOR	-0.0443	-0.0494	0.1110	-0.0059	-0.0116
CAPITAL	-0.0780	-0.2710	0.4316	-0.0241	-0.0602
MATERIALS	0.0896	0.2618	-0.4389	0.0264	0.0627
ELECTRICITY	-0.1718	0.3720	-0.2545	-0.0043	-0.0523
FUELS	-0.0585	-0.5073	0.7060	-0.0381	-0.1053

	QUANTITY				
PRICE	**LABOR**	**CAPITAL**	**MATERIALS**	**ELECTRICITY**	**FUELS**
LABOR	-0.0644	0.1784	-0.1293	0.0025	0.0139
CAPITAL	0.4603	-1.1257	0.7720	-0.0148	-0.0991
MATERIALS	-0.1223	0.5335	-0.4581	0.0101	0.0402
ELECTRICITY	0.0947	-0.5276	0.5261	-0.0221	-0.0746
FUELS	-0.1612	-0.4930	0.6105	-0.0063	-0.0468

CONSTRUCTION

	QUANTITY				
PRICE	**LABOR**	**CAPITAL**	**MATERIALS**	**ELECTRICITY**	**FUELS**
LABOR	-0.0064	0.0191	-0.0168	0.0010	0.0032
CAPITAL	0.0300	-0.3318	0.3811	-0.0206	-0.0608
MATERIALS	-0.0174	0.2919	-0.3460	0.0189	0.0544
ELECTRICITY	0.1593	-0.8630	0.8919	-0.0463	-0.1474
FUELS	0.0778	-0.5889	0.6470	-0.0349	-0.1049

WHOLESALE, RETAIL TRADE

	QUANTITY				
PRICE	**LABOR**	**CAPITAL**	**MATERIALS**	**ELECTRICITY**	**FUELS**
LABOR	-0.0038	0.1097	-0.1056	-0.0009	0.0013
CAPITAL	-0.0057	-0.1990	-0.1927	-0.0014	0.0021
MATERIALS	-0.0041	0.1036	-0.0993	-0.0009	0.0013
ELECTRICITY	-0.9010	5.5392	-4.6706	-0.1003	0.1681
FUELS	-0.0041	0.1154	-0.1111	-0.0009	-0.0014

	QUANTITY				
PRICE	**LABOR**	**CAPITAL**	**MATERIALS**	**ELECTRICITY**	**FUELS**
LABOR	-0.0286	-0.0395	0.0705	-0.0007	-0.0019
CAPITAL	-0.0541	-0.4169	0.5323	-0.0192	-0.0449
MATERIALS	0.0794	0.4347	-0.5741	0.0191	0.0437
ELECTRICITY	0.0028	-0.6516	0.7641	-0.0330	-0.0864
FUELS	-0.0416	-0.6393	0.7823	-0.0307	-0.0748

TRANSPORT AND COMMUNICATION

	QUANTITY				
PRICE	**LABOR**	**CAPITAL**	**MATERIALS**	**ELECTRICITY**	**FUELS**
LABOR	-0.0593	-0.1062	0.1828	-0.0060	-0.0120
CAPITAL	-0.0874	-0.2708	0.4101	-0.0170	-0.0366
MATERIALS	0.1303	0.3645	-0.5651	0.0237	0.0490
ELECTRICITY	-0.0724	-0.3987	0.5520	-0.0254	-0.0580
FUELS	-0.0911	-0.3480	0.5073	-0.0219	-0.0486

MANUFACTURING

	QUANTITY				
PRICE	**LABOR**	**CAPITAL**	**MATERIALS**	**ELECTRICITY**	**FUELS**
LABOR	-0.0271	0.1129	-0.0988	0.0029	0.0108
CAPITAL	0.1066	-0.6539	0.6501	-0.0284	-0.0786
MATERIALS	-0.0733	0.5190	-0.5330	0.0249	0.0658
ELECTRICITY	0.0720	-0.6533	0.7163	-0.0380	-0.1013
FUELS	0.1858	-1.0780	1.0594	-0.0457	-0.1284

SELECTED MANUFACTURING INDUSTRIES

	QUANTITY				
PRICE	**LABOR**	**CAPITAL**	**MATERIALS**	**ELECTRICITY**	**FUELS**
LABOR	-0.0005	0.0005	-0.0030	-0.0027	0.0057
CAPITAL	-0.0012	-0.0020	0.0074	0.0043	-0.0096
MATERIALS	-0.0005	0.0030	-0.0124	-0.0082	0.0181
ELECTRICITY	-0.0569	0.1663	-0.7358	-0.5667	1.1922
FUELS	0.1718	-0.5192	2.4045	1.6239	-3.6785

CHEMICALS, PETROLEUM RUBBER AND PLASTIC

	QUANTITY				
PRICE	**LABOR**	**CAPITAL**	**MATERIALS**	**ELECTRICITY**	**FUELS**
LABOR	-0.0007	0.0019	-0.0072	-0.0048	0.0107
CAPITAL	0.0020	-0.0123	0.0316	0.0182	-0.0395
MATERIALS	-0.0009	0.0044	-0.0123	-0.0071	0.0159
ELECTRICITY	-0.0268	0.1060	-0.3315	-0.2255	0.4773
FUELS	-0.2435	0.1348	-1.5100	-0.6253	-2.2433

NON-METALLIC MINERAL PRODUCTS

	QUANTITY				
PRICE	**LABOR**	**CAPITAL**	**MATERIALS**	**ELECTRICITY**	**FUELS**
LABOR	-0.0005	0.0004	-0.0034	-0.0025	0.0060
CAPITAL	0.0085	-0.0055	0.0139	0.0070	-0.0155
MATERIALS	-0.0011	0.0067	-0.0215	-0.0122	0.0281
ELECTRICITY	-0.0016	0.0186	-0.0539	-0.0299	0.0668
FUELS	0.0022	-0.0308	0.0850	0.0444	-0.1006

METAL PRODUCTS, MACHINERY AND EQUIPMENT

	QUANTITY				
PRICE	**LABOR**	**CAPITAL**	**MATERIALS**	**ELECTRICITY**	**FUELS**
LABOR	-0.0005	0.0012	-0.0038	-0.0027	0.0057
CAPITAL	0.0018	-0.0128	0.0273	0.0149	-0.0311
MATERIALS	-0.0012	0.0062	-0.0147	-0.0084	0.0180
ELECTRICITY	-0.3455	1.0617	-2.8497	-2.2343	4.3627
FUELS	-0.0570	-0.3956	0.1457	-0.0661	-0.3749

OTHER MANUFACTURING INDUSTRIES

	QUANTITY				
PRICE	**LABOR**	**CAPITAL**	**MATERIALS**	**ELECTRICITY**	**FUELS**
LABOR	-0.0006	0.0018	-0.0050	-0.0039	0.0078
CAPITAL	0.0016	-0.0086	0.0180	0.0116	-0.0226
MATERIALS	-0.0011	0.0049	-0.0111	-0.0073	0.0146
ELECTRICITY	-0.0048	0.2578	-0.2652	-0.1939	0.2049
FUELS	0.0258	-0.6247	0.8730	0.4714	-0.7424

RECENT ECONOMIC POLICY/ANALYSIS PAPERS

09-12 Pashardes, P. and A. Polycarpou, “The Labour Market Behavior of Public Assistance Recipients in Cyprus”, December 2012.

08-12 Zachariadis, T. and P. Hadjinicolaou, “The Economic Effect of Climate Change on Electricity Use – A Case Study from Cyprus, December 2012.

07-12 Andreou, S. N., “Analysis of Household Expenditure on Education in Cyprus”, December 2012.

06-12 Papamichael, C. and N. Pashourtidou, “A Monthly Indicator for GDP Growth in Cyprus”, October 2012.

05-12 Ketteni, E., Th. P. Mamuneas and P. Pashardes, " ICT and Energy Use: Patterns of Substitutability and Complementarity in Production ", September 2012.

04-12 Christodoulou, Tr. and S. Clerides, "Emissions-Based Vehicle Tax Reform for Cyprus: A Simulation Analysis ", June 2012.

03-12 Koutsampelas, C., "Measuring the Poverty Risk among Immigrants in Cyprus", April 2012.

02-12 Andreou, S. N., C. Koutsampelas and A. Polycarpou, "The Unified Database of Household Budget Surveys 1984/85, 1990/91, 1996/97, 2003 and 2009 ", March 2012 - in Greek.

01-12 Ketteni, E. , T. Mamuneas, Th. Zachariades and L. Coutinho, "The Effect of EU Energy and Climate Policies on the Economy of Cyprus ", March 2012.

09-11 Ketteni, E. and T. Mamuneas, "Labor Productivity and ICT Capital", December 2011.

08-11 Andreou, N. S., "The Borrowing behaviour of Households: Evidence from the Cyprus Family Expenditure Surveys", December 2011.

07-11 Savva, S. C., "Foreign Direct Investments in Cyprus", November 2011, - in Greek.

06-11 Koutsampelas, C., "Social Transfers and Income Distribution in Cyprus", November 2011.