GENERAL EQUILIBRIUM EVALUATION OF ELECTRICITY MARKET REFORMS IN TURKEY

K. Ali Akkemik

Baskent University, Dept. of Economics

Eskisehir Yolu 20. km Baglica

06810 Ankara Turkey

Tel: +90-506-6040158

Fax: +90-312-2341043

E-mail: akkemik@baskent.edu.tr

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Abstract

The recent attempt to deregulate and liberalize the electricity sector is an important political and economic issue in Turkey. The electricity market in Turkey has been regulated under an autonomous regulator since 2001. Some steps have also been taken to deregulate the electricity market which was previously dominated by public companies. Deregulation in the Turkish electricity sector is still under way and the sector is currently regulated by the regulatory agency to enable smooth implementation of deregulation. Since 2001, competition has been introduced in the electricity generation sector to a significant extent whereas the distribution and transmission stages are highly regulated and controlled almost entirely by public entities. According to the regulation authority, the aim of the recent reform attempts is ensuring the continuity of electricity supply and enhancing efficiency in electricity supply process through increased competition. This paper quantitatively analyzes the impact of these attempts using an applied computable general equilibrium model and a counterfactual full liberalization scenario. The simulation implies that the welfare cost of current regulation is about 1.1 percent of GDP. Full liberalization is found to enhance efficiency in the electricity market, reduce in energy prices for households, and improve consumers' welfare. Empirical findings confirm the policymakers' expectation from the liberalization, i.e., potential efficiency and welfare gains from full liberalization.

1. Introduction

Recent attempt to deregulate and liberalize the electricity sector is an important political and economic issue in Turkey as in many countries. The sector was dominated by a vertically integrated state company until 1984. Since then, the government has undertaken structural reforms to regulate the sector with an ultimate aim of complete liberalization. Since the introduction of private ownership of electricity supply facilities first in 1984, various types of ownership and production structures were observed in the regulated electricity sector. With the establishment of a regulatory agency in 2001 and the adoption of a strategy paper in 2004, deregulation of the sector has taken a start formally. Regulation is generally justified by regulators on the grounds that there are large scale economies and the sector exhibits characteristics of a natural monopoly. Due to entry barriers imposed by the regulatory agency, on the other hand, one may argue that this will cause inefficiency in the sector due to limitations on competition.

Deregulation in the Turkish electricity sector is still under way and the sector is currently regulated by the regulatory agency to enable smooth implementation of deregulation. Since 2001, the government has introduced competition in electricity generation to a significant extent whereas the distribution and transmission stages are highly regulated and controlled virtually entirely by public entities.

Since the ultimate aim of deregulation and liberalization is the establishment of a business environment that works on market mechanism, one expects improvement in efficiency and reduction and elimination of the distortions brought about by the regulation over time. These distortions may be in the form of higher prices for end-users due to inefficiency and biases in resource allocation as represented by the well-known Averch-Johnson effect. The extent of inefficiency in electricity supply in Turkey is yet an area to be explored but Bagdadioglu *et al*. (1996) found that private electricity utilities were more efficient than public utilities in Turkey. Furthermore, Bagdadioglu *et al*. (2007) found potential production efficiency gains (reduction in input usage by 16 percent) as a result of mergers among existing firms in the electricity distribution sector during the period 1999-2003. These studies suggest that there are potential benefits for firms and the sector as a whole from the recent reforms, such as cost reduction and the positive effect on firms motives of production and profits through change of ownership.

Not only the extent of inefficiency but also a more macro view on the reforms in the electricity sector in Turkey is an area that deserves attention. Two previous studies have quantitatively examined the impact of electricity market liberalization with different focuses. Bagdadioglu *et al*. (2007) examined the potential impact of electricity market reform on households, using data from the 2003 Turkish Household Expenditure Survey.

They demonstrate that changing tariff levels or structures have different effects on different regional household groups. According to their analysis, tariff changes may have a significant impact on income of some household groups in some regions and this effect may even be negative depending on the magnitude of the changes. Bahce and Taymaz (2008) examined the consequences of liberalization in the electricity distribution sector using a simulation model. They argue that private distributional monopolies reduce social welfare by restricting output, reducing the sell price and increasing the retail price. They also show that if distributional companies behave as regional monopolists, large welfare losses result in. They conclude that for these reasons there is a need to regulate the electricity the distribution sector favorably by price cap regulation.

This paper aims to examine the effects of liberalization of the Turkish electricity market from a general equilibrium modeling perspective. The impacts of the reforms are examined using an applied computable general equilibrium (CGE) model and a counterfactual simulation. The rest of the paper is organized as follows. The second section reviews the recent reforms in the Turkish electricity sector. Section 3 presents the algebraic features of the model and the data used. Section 4 presents the simulations and their results. Finally, Section 5 concludes.

2. An Overview of Recent Reforms in the Turkish Electricity Sector

Several studies in the recent past have provided reviews of the organizational and legal changes in the electricity sector in Turkey, such as Atiyas and Dutz (2005), Hepbasli (2005), Yilmaz and Uslu (2005), Erdogdu (2007), Cetin and Oguz (2007), and Ulusoy and Oguz (2007). A review of these studies is presented below.

Until 2001, the electricity sector in Turkey was dominated by a vertically integrated public monopoly company, Turkish Electricity Authority (TEK), which engaged in generation, transmission, distribution, and sales. Until 1993 the sector was strongly regulated by the state. In 1993, TEK was split into Turkish Electricity Generation and Transmission Company (TEAS) and Turkish Electricity Distribution Company (TEDAS), both of which enjoyed the status of state-owned-enterprise. Both TEAS and private facilities were allowed to generate electricity but only TEAS and two private concessionary companies were allowed to sell electricity from generators. The period 1994-2001 is characterized by a restructuring attempt where state monopoly was still at the center with a new role as the main buyer of generated electricity.

During the late 1990s, there was a debate about privatizing the generation and trading sectors. In 1999, the Constitution was amended to allow international arbitration in electricity generation. TEAS was split in 2001 into Turkish Electricity Generation Company (TEUAS), Turkish Electricity Transmission Company (TETAS), and Turkish Electricity Trading and Contracting Company (TEIAS) and TEDAS was privatized into 21 regional distribution companies. In the same year Electricity Market Regulatory Agency (EMRA) was established to undertake the reforms towards privatization.

An important milestone in electricity sector reforms is the announcement of the Strategy Paper which set the guidelines for privatization of the electricity sector in March 2004. The Strategy Paper envisaged substantial privatization of public facilities in generation and distribution stages and setting of a tariff system that purely reflects costs. Both of these stages were characterized by strong position of public companies. Strategy Paper admitted that privatization needs to be implemented gradually. The ultimate aim of these reforms is to enable competitive, free market principles. Entry of private investors led to reduction in the share of the public sector from three-fourths in 1999 to around 40-50 percent after 2003.

The current state of the electricity sector can be summarized as follows. Competition in generation and trading sectors was enhanced substantially but transmission sector is still dominated by the state (TETAS) due to the importance of this sector for safe and effective transmission of electricity. In distribution sector, TEDAS and regional distribution companies dominate. Currently, electricity tariffs are regulated by the state and a major principle in setting the tariffs is that tariffs reflect costs. Therefore, costs that do not arise from operation are not included in tariffs. Price regulation implemented by EMRA takes the form of “revenue-cap” regulation in generation and transmission sectors. In the distribution sector and the sales activities, price cap regulation is implemented. In electricity transmission sector, regulated revenues comprise of three main components: (i) system price (cost of the construction, operation and maintenance of transmission assets), (ii) operation price (cost of operation, such as national load dispatch, balancing, settlement, and ancillary services), (iii) connection charge (cost of connection of users to the system) (EMRA, 2003). In the case of electricity distribution sector, the revenue components considered under regulation are (i) system price (cost of construction, operation and maintenance) and (ii) connection charge (cost of connection of users to the system) (EMRA, 2003). The regulated revenues are composed basically of operating costs, depreciation of capital, and an allowed return. In determining the revenue cap, these revenues are taken into account and they are updated by en efficiency improvement factor known as X-efficiency. The figures in Table 1 demonstrate the importance of the electricity sector for Turkey and how rapidly the sector has grown over years. Rapid urbanization and rapid growth of national industries led to rapid growth in electricity demand. During 1995-2005, average annual growth rates of electricity consumption and production were 6.0 and 5.7 percent, respectively, and installed capacity grew by 5.6 percent. Per capita installed capacity and net consumption of electricity grew annually by 4.2 and 4.6 percent. Considering the importance of electricity as an important input in various production sectors and as an important final product for consumers with a presumably low price elasticity of demand, this sector is important for the economy. The government's liberalization program aims to meet the projected large increases in electricity demand.

3. The Structure of the CGE Model

With the above characteristics of the market and given the recent reforms to liberalize the electricity sector, we attempt to investigate the liberalization of the sector and its impacts on the economy using an applied computable general equilibrium (CGE) model. Telli *et al*. (2008) state that environmental modeling applications are relatively new and scarce in Turkey. Such models incorporate energy sectors. But for a thorough analysis of energy market, a detailed representation of the energy sectors is necessary. For this purpose, we develop a 19-sector CGE model where three stages of electricity supply (generation, transmission, and distribution) are included separately. The disaggregation of the electricity sector into these three sectors is a major contribution of this sector as explained in detail in Section 3.1.

General features of the model can be summarized as follows: Economic activities are disaggregated into 19 sectors. A list of these sectors is available in Table 2. Since the focus is on electricity supply, the disaggregation of the economy emphasizes the energy sectors (seven in total which are three electricity sectors, coal mining, petroleum and gas extraction, water supply, and gas supply) and those sectors which use electricity as an important input in production. Compared with similar other studies (e.g., Chisari *et al*., 1999; Kerkelä, 2004; Hosoe, 2006; Telli *et al.*, 2007), this level of disaggregation seems plausible. In production, firms use capital, labor, intermediate materials from other sectors, and energy composite.

In what follows, we first start with the disaggregation of electricity sector and then explain the key features of the CGE model.

3.1. Disaggregation of the Electricity Sector

2002 input-output tables of Turkey, the primary data source for the CGE model, do not distinguish between different sectors of electricity supply. Even the data for electricity sector alone is not available. The data for all utilities sectors (electricity, water, and gas supply) are reported in aggregated form. A model to examine the impact the reforms in the electricity market requires data at higher level of disaggregation. Therefore, it is a major task to disaggregate the data for utilities and electricity first and to disaggregate electricity data into three different stages of supply in the second step.[1]

In disaggregating the electricity sectors, we want it to represent the real world situation as closely as possible. Figure 2 demonstrates the structure of the electricity market after the recent reforms, as described in Cetin and Oguz (2007). In disaggregating the input output data for the utilities sectors, we assume that the only intermediate input for the electricity transmission sector is the total electricity produced by the electricity generation sector. The output of the transmission sector is then used as intermediate input by the electricity distribution sector. However, electricity generation sector can directly sell its output to the distribution sector as well since TETAS is allowed to engage in wholesale of electricity to large industrial final users and private retail companies which then sell the electricity to final users. Under the current regulatory framework, private generators are also allowed to sell electricity to the public distribution company (TEDAS) and regional distribution companies. This complicated system of relations between distribution and generation are fully reflected in the intersectoral transactions in the CGE model. Household consumption of electricity involves only the electricity distribution sector. We also assume that only the generation sector exports electricity and only the distribution sector imports electricity.

Since the input-output tables do not provide data at the disaggregated level, they need to be estimated or obtained from other sources. Total output, capital and labor payments, direct and indirect taxes, exports, imports, and expenditures for material inputs for the generation and distribution sectors are available in *Electricity Generation – Transmission Statistics of Turkey* published by Turkish Electricity Generation and Transmission Corporation. *Energy Statistics* published by the Turkish Statistical Institute (Turkstat) also provides data on the electricity sector as a whole. Using these values and the structure of the electricity market explained above, we reorganize the data to fit them into the structure of the CGE model.

[1] Turkish Statistical Institute seems to posses the input-output data at higher disaggregation but does not disclose them. It is possible that since certain sectors, including the electricity transmission sector, are dominated by a single firm, the statistical institute may be reluctant to disclose such data which they deem as confidential.

3.2. Standard Features of the Model

In this section we describe the algebraic structure of the model without going into further details to save space.[2] The model consists of 19 production and commodity sectors, and three institutions (government, one representative household, and the rest of the world), two production factors (capital and labor).

Production and trade: Figure 2 portrays the production structure of the model. Production involves two stages. At the lower level, value-added (*VA*) composite is modeled with a constant-returns-to-scale function of capital (*K*) and labor (*L*):

$$VA_i = \alpha_{Qi} L_i^{\theta_i} K_i^{1-\theta_i}$$

where α_Q is a shift parameter, θ is the income share of capital, and the subscript i represents production sectors. Value-added is a fixed proportion (b_{ji}) of gross output. Optimum factor demands are derived from first order conditions. We do not include any factor price distortion factors for different sectors due to the factor market closure rule we adopt. In the factor markets we assume that physical capital is sector-specific while labor is perfectly mobile. With this restriction, within a given period, the equilibrium dynamics in factor markets are reached by fixed nominal wages[3] and intersectoral profit rate adjustments. We fix the total labor and capital supplies within a given period. In the dynamic module as explained below, factor supplies are upgraded using the observable data for growth rates of capital and labor.

At the upper level of production, gross output (*Q*) is a Leontief function of value-added, intermediate materials (*MI*), and energy composite. We make an assumption about the substitution of intermediate inputs in production. Intermediate inputs are made up of non-energy and energy inputs. In the energy-producing sectors (coal mining, petroleum and natural gas extraction, and electricity sectors), energy inputs are not substitutable because of the nature of these sectors. Much of the energy used in the electricity generation sector is obtained from natural gas. In other sectors, energy inputs are substitutable. For those sectors we assume constant elasticity of substitution (CES) type of aggregation for energy inputs.

In electricity sectors, as Hosoe (2006) argues, assuming constant returns to scale does

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[2] For brevity not all formulations are reported. Full list of model equations is available upon request.

[3] Telli *et al.* (2008) argue that fixed nominal wage allows for open unemployment and hence helps capture the extent of informalization in the labor market in Turkey, a wide-ranging phenomenon particularly in manufacturing industries.

not seem realistic. These sectors are generally characterized by scale economies. For instance, in the transmission stage of electricity supply, the investments to improve the network facilities will create positive externalities for both industrial users which directly receive electricity from the transmission lines and for the distribution system as the quality of the transmission service improves. Another reason for the existence of scale economies in the electricity sectors is the high fixed costs.[4] For this purpose, we assume increasing returns to scale in the three electricity sectors and constant returns to scale in the remaining 16 sector.[5] We denote the three electricity sectors as *j*, which is a subset of *i*.

Gross output in CGE models refers to the monetary value of the physical output and therefore includes all types of earnings on production. As we assumed increasing returns to scale on the electricity sectors, these sectors earn a markup over marginal cost. The allowed real rate of return for the regulated electricity sectors is modeled as a markup (μ) on capital earnings apply to all three sectors:

$$p_{Kj}K_j = (1+\mu_j)\,p_{Kj}^0 K_j^0$$

where *j* refers to the three electricity sectors, and the bars over letters represent the case of perfect competition. This markup is imposed on consumer prices of electricity distribution. Although these markups may differ across the three electricity sectors, due to lack of empirical estimates of we assume a uniform rate of 10 percent.

For trade accounts, we assume that Turkey is a "small country" and cannot affect world prices. Gross output is either sold in the domestic market or exported. The transformation of exports (*X*) and domestic sales (*D*) in this way takes the form of a constant elasticity of transformation (CET) function as follows:

$$Q_i = \alpha_{Ti}\left[\beta_{Ti} X_i^{-\rho_{Ti}} + (1-\beta_{Ti}) D_i^{-\rho_{Ti}}\right]^{\frac{1}{\rho_{Ti}}}$$

where ρ_T , α_T, and β_T refer to CET elasticity parameter, shift parameter, and distribution parameter, respectively. Domestic goods and imports (*M*) form the Armington composite good (*E*) with a production relation characterized by the Armington-type of

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[4] Many studies have examined the extent of scale economies in electricity sectors in different countries using econometric methods (e.g., Nemoto *et al.*, 1993; Salvanes and Tjotta, 1994; Filippini and Wild, 2001; Estache *et al.*, 2002).

[5] Konan and van Assche (2007) make a similar assumption for the regulated sector in their analysis of regulation and service trade liberalization in Tunisian telecom sector. See also Hoffman (2002) on modeling imperfect competition in CGE models.

constant elasticity of substitution (CES) function:

$$E_i = \alpha_{Ei}\left[\beta_{Ei} D_i^{-\rho_{Ei}} + (1-\beta_{Ei}) M_i^{-\rho_{Ei}}\right]^{-\frac{1}{\rho_{Ei}}}$$

where ρ_E , α_E, and β_E refer to Armington elasticity parameter, shift parameter, and distribution parameter, respectively. Both Armington and CET specifications assume imperfect substitution between traded goods and domestic goods. Electricity is a traded good as well. We assume that export revenues accrue to the distribution sector. Similarly, payments for imported electricity are done by the distribution sector.

The optimal combinations of exports and imports relative to domestic supply are calculated from the first order conditions using prices and elasticities of CET and Armington functions above:

$$\frac{M_i}{D_i} = \left(\frac{\beta_{Ei}}{1-\beta_{Ei}} \cdot \frac{p_{Di}}{p_{Mi}}\right)^{\frac{1}{1+\rho_{Ei}}}$$

$$\frac{X_i}{D_i} = \left(\frac{\beta_{Ti}}{1-\beta_{Ti}} \cdot \frac{p_{Xi}}{p_{Di}}\right)^{\frac{1}{\rho_{Ti}-1}}$$

Export prices (p_X) and import prices (p_M), are defined as:

$$p_{Mi} = p_{Mi}^{*}(1+t_{Mi})ER$$

$$p_{Xi} = p_{Xi}^{*} ER$$

The prices with an asterisk (*) are world prices and *ER* is the exchange rate defined as the price of US dollar in terms of New Turkish Lira.

Institutional demands and savings: The model assumes a representative household and does not distinguish between different household groups. Since the effect of liberalization on income distribution is not a concern of this paper, we do not disaggregate households. The representative household consumes composite goods with a Cobb-Douglas type of utility (U) function as follows:

$$U = \prod_i C_i^{\alpha_{Ci}}$$

where C and α_C refer to consumption level and consumption share of good *i* in total household consumption expenditures. Household composite good consists of energy and non-energy goods.

Factor income from the delivery of capital and labor services accrue to households as household income (Y_H). Labor income is calculated as the sum of labor payments by sectors (determined by wage, *w*, and employment, *L*) net of direct taxes (determined by direct tax rate, t_D, and sectoral output, *Q*) and capital income is calculated as the sum of capital earnings (real rental rate *r* multiplied by sectoral capital stock *K*):

$$YH = \sum_i w_i L_i - \sum_i t_{Di} p_i Q_i + \sum r_i K_i$$

Households distribute this income between consumption expenditures and savings. Household savings are assumed to be a constant ratio of their income and we also assume that sectoral shares in household consumption are fixed.

The government earns tax revenues from firms and households and spends this income on its current expenditures and in its transfers to households (social security payments). We assume that both government expenditures and revenues are endogenously determined. It is a common practice in some CGE studies such as Hosoe (2006) to set the government's expenditures exogenously, which fixes government consumption and investments are at their benchmark level in order to measure the pure impact of the regulatory reforms on household utility. We set the ratios of government consumption and investments to GDP as exogenous and let the model determine their levels based on the calculated GDP.[6] The government collects direct and indirect taxes from households and uses these revenues to finance its expenditures (*G*):

$$\sum_i p_i G_i = \sum_i t_{Mi} M_i + \sum_i t_{Di} p_i Q_i + \sum_i t_{IDi} p_i Q_i$$

Indirect taxes and direct taxes are computed by multiplying indirect tax rate (t_{ID}) and direct tax rate (t_D) by output. Import revenues are found by the product of import tariffs (t_M) and imports. The shares of goods in total government expenditures are fixed. It is important to note that the excess revenues from the markups that arise from the regulation of the electricity sectors are not transferred to the government budget. The public companies use these excess revenues for their own productive activities.

Equilibrium conditions: The equilibrium conditions for the goods market, factor market, and investment and savings are specified as follows. In the goods market, aggregate demand equals gross output as follows:

$$MI_i + C_i + G_i + I_i = Q_i$$

Aggregate demand comprises of household consumption, government consumption, intermediate input demand, and investment demand (*I*). In the factor market, sectoral factor demands sum up to total factor supply.

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6 It is also possible to impose an exogenous primary surplus to GDP ratio of 6.5 percent as stated in the stand-by agreement of Turkey with the IMF (see Telli *et al.*, 2008).

Total investments are made up of public (I_P) and private investment (I_G). Investments are financed by savings which is made up of household savings (S_H), foreign savings (S_F), and public savings (S_G):

$$\sum_i I_{Pi} + \sum_i I_{Gi} = S_H + S_F + S_G$$

Public savings are set as exogenous. The amount of total savings is also set exogenous and the capital inflows from the rest of the world (i.e., current account) are assumed to adjust the saving-investment equilibrium. Since Turkey is a highly open economy, this assumption is not unrealistic. Private investments are calculated endogenously.

Foreign exchange market is assumed to clear with flexible exchange rate. The sum of exports, foreign savings, and net transfers from abroad (TRN_F) equals imports:

$$\sum_i p^*_{Mi} M_i ER(1 + t_{Mi}) = \sum_i p^*_{Xi} ERX_i + S_F + TRN_F$$

Numeraire: The CGE model computes relative prices of the system. Normalization of prices is done by exogenously setting the supply prices as follows:

$$PI = \sum_i \Omega_i P_i$$

where Ω is the share of each sector in total gross output, PI is the general price level (price index) and P is an index of producer (gross output) prices. With the Walrasian structure of the model, the model solves for real prices in terms of producer prices.

Rate of return regulation: A hybrid system of rate-of-return regulation and revenue-cap regulation is implemented in the Turkish electricity sector. The earnings of the firms in the electricity sector are subject to regulation on their revenues. The regulatory authority (EMRA) equals these revenues to the sum of operating costs, depreciation of capital, and an allowed return on capital earnings. In revenue cap regulation, the regulator uses inflation minus the efficiency factor to the revenue cap. Prices are allowed to change only by this amount. A third exogenous component can be added for all other costs that the regulator cannot control. This system is generally implemented to provide incentives for the regulated firms to enhance their efficiency in order to increase their profits. The efficiency factor is representative of the average firm in a competitive market. As stated before, the allowed real rate of return to capital is set at 10 percent. In the model, the price of capital in electricity sectors reflects regulation as shown in equation (3).

3.3. Data and Calibration

The main database used in numerical solutions is the 2002 Social Accounting Matrix (SAM). An aggregated macro-SAM7 is presented in Table 3. The SAM is organized as an extended input-output table using 2002 Input Output Tables of Turkey which were published in 2008 by Turkstat. Data on the institutional accounts are calculated using the data from the national accounts, general budget account, and social security data, which are available from Turkstat and the Central Bank of the Republic of Turkey Data Delivery System. Numerical values of the important parameters used in the model are calibrated in the standard fashion using observed data and the behavioral equations of the model. The shares of labor and capital in production (distribution parameters in the production function), indirect tax rates, import tariff rates, income tax rate, and tax rate of capital income are calculated directly from the SAM.

4. Policy Simulation

4.1. Counterfactual Scenario

The general aim of liberalization is to establish a competitive market and to ensure better allocation of resources and hence improve efficiency. Liberalization in the electricity market is expected to reduce costs of production through efficient operation of generation and distribution facilities, improve the quality of services through competition, and ensure the continuity of electricity production through upgrading of existing facilities or undertaking new investments.

The model whose specific features are explained in the previous section can be used to analyze the effects of the liberalization in the Turkish electricity market. For this purpose, we run a counterfactual scenario where the regulation in the electricity sectors is removed. This is realized in the model by dropping the markup rate. The degree of inefficiency in the electricity sectors, however, is kept at the benchmark level. The model allows us to quantitatively measure the cost of regulation. Efficiency gains expected from the liberalization of the electricity market can be measured by the reduction in intermediate input use as percent of total sales of gross output. This is because output is modeled as a Leontief function of value-added and intermediate inputs. As well as macroeconomic issues such as unemployment, we are specifically interested in efficiency changes in electricity sectors due to their impact on other sectors. Ex ante, we expect to find efficiency increase, reduction in consumer prices of electricity, reduction in energy input costs for production sectors, and a reduction in factor demand due to enhanced efficiency. Finally, we expect to find an improvement in the level of national welfare due to such efficiency gains. It is not intended in this paper to model alternative paths of deregulation. The counterfactual scenario described here assesses only the final result of total removal of regulation.

4.2. Simulation Results

Macroeconomic results of the simulations are reported in Table 4. Sectoral results for the variables of interest are reported in Table 5. Changes in the electricity sectors are passed on to other sectors due to intersectoral linkages. The results in Table 4 demonstrate that they amount to a moderate percent (0.53 percent) of GDP.

Removing the distortions in the electricity sectors, which we hypothesized to result from regulation, utility measured by Hicksian equivalent variations improve by 1.08 percent of GDP. This means a welfare improvement by this amount. Energy composite prices decline by 13.5 percent for households, which leads to about 17.2 percent rise in the household consumption of energy composite. Aggregate wage and profit rate levels rise by 0.56 and 0.79 percent, respectively.

Full liberalization of the electricity sectors decreases the supply prices in the electricity generation sector by 3.8 percent and in the electricity distribution sector by 11.7 percent. Efficiency gains, measured by the reduction in the intermediate input use, are 5.4 percent in the electricity generation sector and 7.2 percent in the distribution sector. The inefficiency in the transmission sector prevails.

Energy composite price declines in services and some manufacturing sectors. Note that households cannot substitute electricity perfectly with other sources of energy, the decline in electricity prices are reflected in the declining consumption of energy by households and hence declining utility levels.

In response to the decline in electricity supply price, the level of output in the electricity generation and transmission sectors are reduced. It should be noted that output in the generation depends on available resource supply, mainly water and natural gas. This is a major constraint for the adjustment of output when demand changes. Although producers can adjust output between exports and domestic supply, we fixed the level of exports of generated electricity in the model since electricity export is determined by international agreements. The negative impact on output of electricity generation and transmission sectors is compensated for by output gains in other sectors. The change in total gross output in the economy is 0.1 percent while GDP changes by 0.5 percent. Output level increases generally in the sectors more dependent on electricity as an input (e.g., metals, oil-gas, utilities, and other manufacturing sectors). In other words, the results of the simulation can be interpreted such that the current regulation of the electricity sector limits the potential of these sectors. Overall, we conclude that the output effect of the deregulation is moderate.

Wage rate rises by 0.56 percent and profit rate decreases by 7.1 percent in the electricity generation sector. Removing the regulation reduces profit rate in electricity generation. In the transmission and distribution sectors, the change in the profit rate is minimal. Since we assumed capital immobility across sectors, profit rates adjust. Profit rate declines in the coal sector by 7.8 percent. On the other hand, rates of return increase in energy-intensive sectors (i.e., metals, fabricated metals, utilities, and oil-gas). Economy-wide, average profit rate is affected positively by 0.79 percent. Labor demand is reduced in nine sectors including electricity generation, transmission, construction, and coal. Labor released from these sectors, is reallocated to the remaining sectors which include metals, utilities, electricity distribution, oil-gas, and services. However it should be noted that these labor shifts are not significant since the amount of labor released is very small and those sectors releasing labor account for a very small share of employment.

Due to positive impact of deregulation on factor prices, direct tax revenue of the government rises by 13 percent. It is noteworthy that due to the models assumptions about factor market closures, distribution of income between owners of capital and owners of labor remains unchanged. On the other hand, increased capital and labor income translates itself to higher household income and therefore to increased aggregate consumption (about 1.7 percent).

4.3. Sensitivity Analysis

Often in CGE models the results of experiments are sensitive to key model parameters. We examine the response of main variables of interest to different values of the selected key parameters. For this purpose we designate a range of values for selected levels of inefficiency in the electricity generation sector. The results are presented in Table 6. The figures in the table demonstrate that the results are not very sensitive to different levels of this parameter. On the other hand, it is observed that the higher the degree of inefficiency the higher the economic gains but in small amounts.

Concluding Remarks

Due to projections of rapidly increasing demand for electricity in the near future, Turkey has undertaken reforms to deregulate the electricity market after 2001. The main aim of the recently announced electricity sector strategy of the government is to ensure continuity of electricity supply and enhance efficiency in electricity supply process through enhanced competition in the market.

The current paper quantitatively analyzes the impact of deregulation on the economy using a CGE model. The results of the full liberalization scenario imply that the output cost of current stage of regulation in the electricity sector amounts to about half a percent of GDP and welfare cost is about one percent of GDP. These are moderate but still positive figures. Full liberalization is found to result in efficiency gains in the electricity market, reductions in energy prices for households, and an improvement in utility level of the consumers. Reduced electricity prices affect the electricity generation and transmission sectors negatively but those industries that are dependent on electricity positively. Empirical findings draw a positive picture for the results of deregulation and confirm the strategy paper which states that there are potential efficiency and welfare gains from full liberalization.

Distributional implications of liberalization are not dealt with in this study. The impacts on different households may have some implications for policymakers. These and some other considerations (such as environmental issues) may further improve the model findings and future line of research should focus on such issues. In addition, certain issue related to the nature of the electricity generation and transmission processes such as capacity related problems are ignored in this study due to their irrelevance for the policy discussed. They remain mostly technical issues to be dealt with but further examination of such issues may also have implications for policymakers.

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Table 1. Electricity Production and Consumption in Turkey

Year	Installed capacity (MW)	Electricity generation (GWh)	Consumption (GWh)
1985	9119	34219	29709
1990	16315	57543	46820
1995	20954	86247	67092
2000	27264	124922	98296
2001	28332	122725	97070
2002	31846	129400	102948
2003	35587	140581	111766
2004	36824	150698	121142
2005	38844	161956	130263

Source: State Planning Organization, *Economic and Social Indicators 1950-2006* and State Statistical Institute, *Statistical Indicators 1923-2004*

Table 2. List of sectors in the model

Sectors	Acronyms	Corresponding sector codes in the input-output tables
Agriculture	Agr	01, 02, 05
Coal, lignite, peat	Coal	10
Oil, gas, refined oil products	Oil-gas	11, 23
Other mining	Min	12, 13, 14
Food manufactures	Food	15
Textile	Tex	17
Paper and printing	Paper	21, 22
Basic metals	Met	27
Fabricated metals	Fabmet	28
Electrical machinery	Elmach	30, 31, 32
Other manufacturing	Oth-man	16, 18, 19, 20, 24, 25, 26, 29, 33, 36, 37
Transportation services	Tran	34, 35, 50, 51, 52, 60, 61, 62
Electricity generation	Elec-G	40
Electricity transmission	Elec-T	40
Electricity distribution	Elec-D	40
Water and gas supply	Util	40
Financial services	Fin	65, 66, 67
Construction	Cons	45
Others	Other	41, 55, 63, 64, 70, 71, 72, 73, 74, 75, 80, 85, 90, 91, 92, 93, 95

Table 3. Aggregated SAM for 2002 (unit: billion New Turkish liras)

	Activities	Commodities	Households	Government	Rest of the world	Investment	Tariffs	Indirect taxes	Value-added tax	Capital	Labor	*ROW SUM*
Activities		530.3			62.1							592.5
Commodities	273.4		216.8	42.9		106.8						639.8
Households			110.9	14.0	7.6					214.0	92.5	439.0
Government			24.2	0.0			0.7	12.5	27.0			64.5
Rest of the world		81.8	18.8	5.8								106.3
Investment			68.4	1.8	36.6							106.8
Tariffs		0.7										0.7
Indirect taxes	12.5											12.5
Value-added tax		27.0										27.0
Capital	214.0											214.0
Labor	92.5											92.5
COLUMN SUM	592.5	639.8	439.0	64.5	106.3	106.8	0.7	12.5	27.0	214.0	92.5	

Table 4. Macro results

Variable	Percentage change relative to the benchmark solution
Energy prices for households	-13.53
Energy composite use by households	17.16
Equivalent variations / GDP (%)	1.08
Exchange rate	-3.52
Direct taxes	12.21
Savings	-1.11
GDP	0.53
Consumption	1.77
Profit rate	0.79
Wage level	0.56

Table 5. Sectoral results for the counterfactual simulation (Percentage changes from the baseline solution)

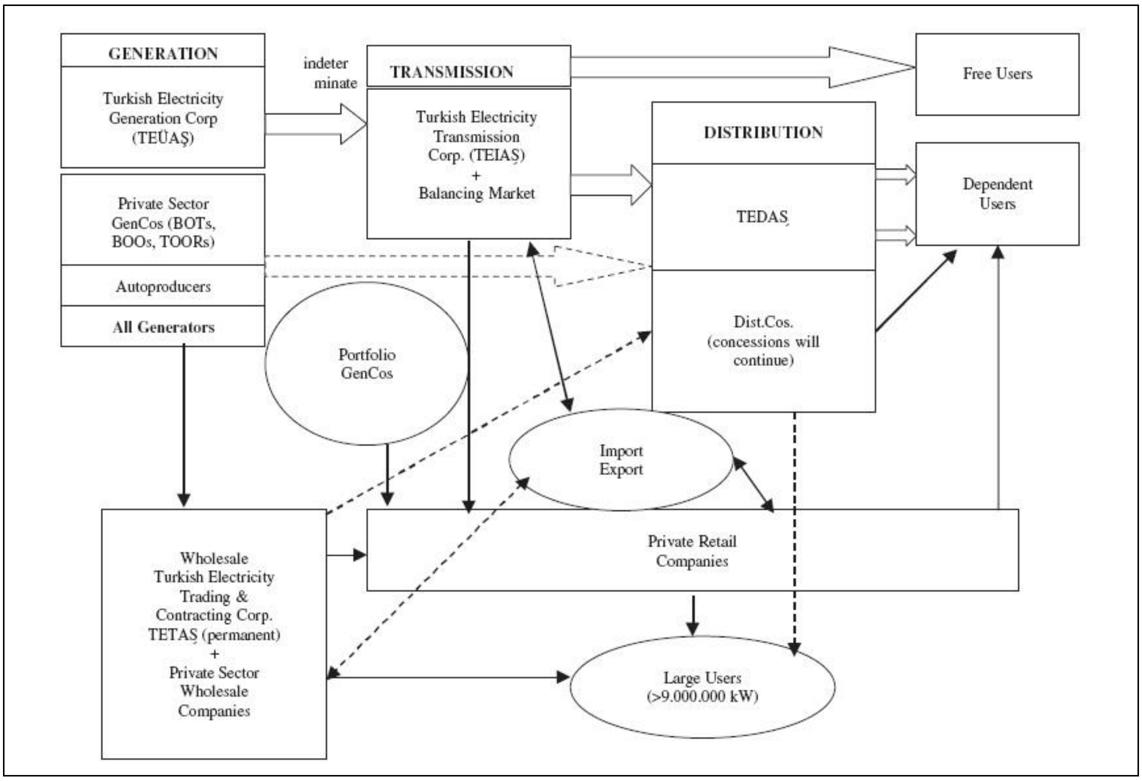
	Q	*MI*	*C*	*L*	*E*	*P*	P_E	*r*	*w*	*E*(*en*)	P_E(*en*)
Agr	0.1	0.3	0.7	0.8	0.4	0.9	0.6	1.38	0.56	0.13	0.18
Min	-0.5	0.0	0.0	-1.7	0.0	-0.8	-3.6	-1.20	0.56	-0.54	0.15
Food	0.3	0.3	1.0	1.0	0.6	0.4	0.3	1.60	0.56	0.31	-0.55
Coal	-6.7	-22.8	5.5	-8.3	-6.4	-1.4	-4.0	-7.83	0.56	0.00	0.00
Oil-gas	0.5	-0.5	10.8	2.1	1.0	0.6	0.3	2.70	0.56	0.00	0.00
Oth-man	-0.2	0.0	2.1	-0.5	0.7	-0.9	-0.8	0.02	0.56	-0.23	-0.32
Tex	-0.5	-0.3	2.5	-1.3	0.2	-0.6	-1.1	-0.73	0.56	-0.47	0.19
Met	1.5	0.1	16.4	3.9	0.1	-3.5	-12.9	4.47	0.56	1.48	-0.49
Fab-met	0.7	-0.6	5.1	1.7	-0.2	-3.4	-3.6	2.25	0.56	0.69	0.21
Cons	0.0	0.3	2.5	-0.1	0.0	-1.0	-1.1	0.49	0.56	-0.02	0.20
Elec-G	-5.8	-5.4	0.0	-9.3	-5.4	-3.8	-3.8	-7.09	0.56	0.00	0.00
Elec-T	-7.2	5.8	0.0	-7.2	5.8	0.2	0.2	0.00	0.56	0.00	0.00
Elec-D	5.8	-7.2	0.0	5.8	-4.1	-11.7	-11.7	0.00	0.56	0.00	0.00
Util	0.8	-13.3	8.8	6.5	1.8	5.6	-9.3	7.10	0.6	-7.6	0.0
Elmach	-1.2	-5.5	3.9	-2.8	-1.4	-2.1	-2.5	-2.25	0.56	-1.03	-1.37
Fin	0.1	-0.2	1.9	0.4	0.4	0.4	-0.6	0.99	0.56	0.87	0.02
Tran	-0.1	-0.5	1.5	-0.6	0.3	-0.3	-0.2	-0.03	0.56	0.09	0.01
Paper	1.7	0.4	7.3	4.0	1.7	-0.2	-5.5	4.63	0.56	2.92	0.19
Other	0.6	0.2	1.6	1.6	0.7	0.8	-0.3	2.17	0.56	1.55	-0.25

Note: *Q*: output, *MI*: intermediate inputs, *C*: consumption, *L*: employment, *E*: Armington composite, *P*: supply price, $P_{E:}$ composite price, *r*: Rental rate of capital, *w*: wage, *E*(*en*): Energy composite, P_E(*en*): Energy composite price

Table 6. Sensitivity analysis for the CGE results

	Degree of inefficiency in the electricity generation sector			
	15 percent	20 percent	25 percent	50 percent
Energy prices for households	-13.53	-13.53	-13.53	-13.52
Energy composite use by households	17.16	17.16	17.16	17.17
Equivalent variations / GDP (%)	1.088	1.089	1.090	1.093
Exchange rate	-3.557	-3.556	-3.556	-3.555
Direct taxes	13.007	13.001	12.995	12.973
Savings	-1.181	-1.190	-1.199	-1.229
GDP	0.526	0.527	0.528	0.531
Consumption	1.774	1.775	1.777	1.782
Profit rate	0.794	0.792	0.791	0.787
Wage level	0.569	0.557	0.565	0.556

Figure 1. The structure of the electricity market in Turkey with the new reforms



Source: Cetin and Oguz (2007)

Figure 2. Production structure of the CGE model