CHAPTER 4

Modeling for Green Growth: Environmental Policy in a Dualistic Peripheral Economy

The main methodological apparatus of this study is now introduced. The overall characteristics of this quantitative and analytical approach and initially introduced, and its salient features are discussed in contrast to alternative modeling techniques that have been reported in the literature. This modeling framework rests on the theoretical basis of general equilibrium with various economic activities across many markets, as interplayed by diverse actors, households, producers, governmental bodies, and the foreign economy.

Thus the focus of this chapter is on the nature and consequences of the dynamic interplay of general equilibrium interactions. It is set within the context of structural characteristics of a developing economy (i.e., Turkey) to reveal regional stratification and duality. The analytical approach is based on the methodology of applied general equilibrium distinguished as the folklore of computable general equilibrium (CGE). The methodological rationale is based on the urgent need to improve understanding of the complex trade-offs between attaining sustainable development, mitigating the threat of climate change, and enhancing social welfare. The need to identify an analytical resolution for ranking alternative policy instruments and interactions from the point of view of social welfare and economic well-being will also be addressed.

The CGE modeling methodology is the most conducive analytical apparatus for capturing these diverse objectives and policy trade-offs within the discipline of general equilibrium theory. Embedded in the theoretical realm of the Walrasian equilibrium, the CGE framework provides a coherent system of data management and scenario analyses to simultaneously address issues of sustainability and mitigation.

The concept of developmental sustainability is a fairly recent phenomenon that came into development economics through the 1987 report of the *World Commission on Environment and Development* led by the *Brundtland Commission*. The Brundtland report succinctly summarized the concept as

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"… development which meets the needs of the present without compromising the ability of future generations to meet their own needs." Sustainability has since become one of the most influential phrases of the environmental policy agenda.

Thus what is needed is a coherent analysis of the systemic relations surrounding the energy–economy–environment (3E) nexus. Thus the CGE framework is utilized as a social laboratory tool for addressing policy questions over the 3E realm.

4.1 THE CGE FOLKLORE

The CGE methodology is an applied approach to the Walrasian economic system. It is *Walrasian* in the sense that it brings behavioral assumptions, production technologies, and market institutions together within the discipline of general equilibrium. Along with equilibrium production processes, it also brings factors of production (i.e., capital, labor, and energy aggregate input) within a dynamically adjusting technological pathway.

Commensurate with production activities, incomes are generated through wages, profits, and other factor payments. Income remunerations are channeled to the households whose role in the system is to dispose of the generated factor income through (private) consumption expenditure on commodities or (private) savings. Saving funds are, in turn, disposed of as investment expenditures on fixed capital to accentuate the potential output in the next production cycle.

Following the identification of national income accounting, any gap in the domestic savings–investment balance is met by foreign savings; that is, the balance on the current account of the balance of payments. Adjustments on a flexible (real) exchange rate (conversion factor of the price indexes of domestically produced versus foreign goods), or quantity adjustments on foreign exchange flows, are possible modes to bring forth the warranted equilibrium. Governments are institutionalized in every aspect of economic activity considered thus far. Through the administration of taxation or subsidization, governments can act as economic agents to fulfil public expenditure or saving accounts, and function as administrative units to design alternative policy scenarios and implement instruments of abatement. The CGE framework has the capability to provide an economic evaluation of "what if?" policy interventions under various abatement scenarios.

Thus given their structural flexibility and theoretical consistency, CGE models have become standard tools for the quantitative analysis of policy inference by international agencies (i.e., the Organisation for Economic Co-operation and Development (OECD) and the World Bank) and numerous national bodies of developmental and environmental policy. Deeper surveys are provided by Bergman (1990), Bhattacharyya (1996), Böhringer and Löschel (2006), and Shoven and Whalley (1992).

Chapter 2 briefly discussed the basic dual-economy model and the models of structural transformation, building on the earlier works of Higgins (1956), Jorgenson (1961, 1966, 1967), Lewis (1954), and Ranis and Fei (1961). The CGE literature offers a sophisticated platform to study the basics of the dual-economy model, such as interdependencies among different sectors of the economy, productivity differences between modern and traditional sectors, patterns of unemployment and underemployment, labor market imperfections, and dynamics of (qualitatively) different types of growth-capital accumulation. With high levels of data disaggregation, CGE models also provide substantial gains in the move towards more realistic structures (de Melo, 1977; Sue Wing, 2004; Temple, 2005).

The reflection of the model on "modern sector dualism" puts considerable focus on labor market (or market) imperfections, of which the effects project onto the labor markets. Imperfect or segmented labor markets have implications for sectoral production structures, sectoral productivity differentials, and aggregate outcomes (Temple, 2004). Multisectoral CGE models are therefore useful, and required, in the analysis of interactions between urban unemployment, informal sector size, and structural transformation and economic growth patterns.

Understanding structural change and its determinants clearly has direct policy implications. Applied multisectoral general equilibrium models that provide detailed accounts of the economic structure in developing economies are often used to assess policy alternatives and have long-term impacts (i.e., climate change). These models offer a framework with multisectors, different production structures, detailed representations of the labor markets, possible migration dynamics, and regional specialization. They are also capable of providing modern accounts of the interactions between long-term structural transformation and the distribution of welfare. Hence CGE models with basic "dualistic" structures are extensively utilized to study inequality and poverty.

Representation of the well-documented features of the labor market in developing countries (i.e., wage efficiency, a large informal sector, labor market segmentation, a heterogeneous and imperfectly mobile labor force, and wage flexibility in the informal sector) allows these models to study the strong links between the structure of the labor markets, the transmission of policy shock, and inequality and poverty (Agénor, 2004). Many classical CGE models work with homogenous labor markets with a fixed supply of labor and flexible wages; however, the models that aim to analyze poverty and the poverty-reduction implications of policies (i.e., trade liberalization, structural adjustment, and social transference) engage in more detailed representation of the labor market, often accompanied with other dualistic attributes of developing economies.[1]

The representation of labor heterogeneity through the distinction between formal and informal and urban and rural labor under various degrees of substitution forms the basic approach for developing "dual labor market" structures in applied general equilibrium modeling (Graafland et al., 2001; Hendy and Zaki, 2013). The basic idea of the Harris and Todaro (1970) framework, which stated that urban–formal and rural–informal labor markets are not completely isolated from each other but are connected via (imperfect) labor mobility, has also been extensively utilized in CGE models studying poverty and inequality (Agénor et al., 2003; Alzua and Ruffo, 2011; Gilbert and Wahl, 2002; Yang and Huang, 1997).

The "dual–dual" structure adopted by Thorbecke (1993) not only uses the formal–informal labor characterization of these CGE models but further introduces coexisting modern and informal activities in both urban and rural areas, which is usually the case for typical middle-income developing economies (Khan, 2004). Stifel and Thorbecke (2003) provide an example model of an archetype African economy to simulate the welfare effects of trade liberalization on poverty. The presence of dualism (modern and informal activities) within each sector makes it possible to analyze the distribution of both activities in rural and urban areas. Hence the single modeling framework captures a subsistence agriculture using traditional labor-intensive technologies, a large-scale capital-intensive agriculture producing mostly export goods, the urban–informal sector, and the urban–modern sector.[2]

[1] Boeters and Savard (2012) provide a detailed review of alternatives for modeling labor markets in CGE models.

[2] Khan (2004) provides further discussion on the characteristics of applied general equilibrium models for poverty policy analysis in the context of developing countries. He emphasizes the importance of representing typical features including, market power, the role of intermediate and capital goods, the structure of financial systems, and the roles of labor markets and the informal sector.

Structuralist models, which focus on the role of demand to understand structural transformation, also provide examples of formal and informal production structures in developing economies. Rada and von Armin (2014) and Morrone (2016) performed studies in India and Brazil, respectively. They highlighted the existence of formal and informal production activities with differentiated productivity levels, and emphasized the role of the informal sector in supplying the reservoir of labor for understanding the complexity of structural transformation dynamics in a middle-income developing economy. In a different framework, Roson and van der Mensbrugghe (2017) emphasized the importance of distinguishing between the supply-side effects (which affect sectoral productivity and growth dynamics) and the demand-side effects (which capture the variations in the structure of final demand) for understanding structural transformation. Their results indicate that time-varying and income-dependent demand structures generate sizable variations in the industrial structure.

The relevance of regional modeling and regional CGE models in representing and analyzing the spatial distribution of "dualistic" structures, and the implications of such distributions on the structural transformation and geographical distribution of welfare in developing economies, should be noted. Regional and multiregional CGE models that emphasize the roles of the spatial distribution of production activities and (endogenous and imperfect) interregional migration contribute to our understanding of differentiated development paths. Many regional CGE modeling reviews are available; however, Donaghy (2009), Giesecke and Madden (2012), Kraybill (1993), and Partridge and Rickman (2010) provide the basis for understanding the effects of incorporating key regional features (i.e., regional labor markets and interregional migration) into structural transformation models.

The CGE approach is not the only method for quantitatively modeling the economics of climate change. A wide arsenal of quantitative methods exist to assess the complex set of interactions over the 3E nexus; however, a thorough survey is beyond the main focus of this study. Nevertheless, a brief synopsis of the alternative methods is instrumental in placing the CGE methodology in the right framework to emphasize its advantages and misconceptions.

The so-called macroeconometric models, mainly of Keynesian tradition, have close affinity with the CGE model. These models rely on large datasets, often with long time series, and are amenable to statistical inference and probabilistic hypothesis testing. However, they typically fail to capture the cause–effect relationships between the economic machine and environmental pollution, and their analytical power at ranking the welfare implications of the policy instruments of abatement is rather limited. The CGE framework, with its theoretical basis laid out over the Walrasian general equilibrium foundation, can accommodate the structural cause–effect hypothesis over a wide range of behavioral motives and endogenous market signals. Furthermore, with their ability to make "what if?" assessments against a "business-as-usual" trajectory, their simulation exercises offer a viable metric for ranking the cause–effect impact of alternative policy regimes that combat climate change and mitigation.

Conversely, the nature of CGEs means that they can accommodate energy sector activities through their production functions and characterize economic behavior in response to the cost minimization impulses of "rational agents." The CGE apparatus typically only addresses the workings of the energy system through the cost-value system of economic relations and, as such, may fail to provide sharp flows of the technical aspects of energy production and distribution.

An alternative take on the technical attributes of the energy system is accomplished by the bottom-up approach of modeling. In contrast to the top-down CGE analysis, the bottom-up models attempt to capture the technical nature of the substitution possibilities and input requirements across the primary and final sources of energy production and distribution. They focus exclusively on substitution and input requirements to produce a given energy throughput. As the cheapest method of energy substitutes, they attempt to offer the most efficient energy production technique that would indirectly serve as abatement projections.

However, a major deficiency of bottom-up methods is their lack of ability to address energy–economy interactions. In particular, working typically within the constraints of fixed final demands, they do not accommodate feedback mechanisms from the economy to the energy system. In addition, they fail to offer much on the warranted implications of the policy instruments on the rate of growth, employment, and the path of capital investments (the rebound effect).

However, it should be noted that this arguably diverse dichotomy does not necessarily pertain to a theoretical departure, but in the words of Böhringer and Löschel (2006, p. 50) it may "…simply relate to the level of aggregation and scope of ceteris paribus assumptions." There have been various attempts to merge both approaches within a mega-framework, embedding the bottom-up energy module with the Walrasian general equilibrium system of the simultaneous equations of a CGE (Böhringer, 1998; Manne, 1981).

Therefore there is not a single all-encompassing methodology. Starting with the general equilibrium theory for the socially-efficient instruments of abatement under informalization and duality within the context of the Turkish economy applied here, more steps ought to be investigated to advance our understanding of the complex dynamics between economy, society, and the environment.

4.1.1 Modeling the 3E Nexus via CGE Analytics

The version of the CGE model utilized in this study uses various methods to address the characteristic features of peripheral development and the dual objectives of development and environmental abatement. One distinguishing feature of the current model is that it deliberately recognizes regional differentiation in employment and production to accommodate the traps of poverty and technological backwardness. Turkey can be used as a viable example of a peripheral economy with a key mandate for sustaining energy sufficiency and generating growth and employment. However, the country is currently facing strong international pressure to bring its gaseous emissions under control. These constitute the main traits of the Turkey CGE model to be utilized in this study.

The model also takes account of the rigidities in the labor and capital markets by introducing explicit gaps against the equalization of the wage and profit rates across sectors. These "distortions" are set from the existing data on wage rates (and profit rates) across sectors, and are maintained as rigid divergences from equalization of the "average" wage rate. Migration is a further behavioral rule, which governs the movement of labor from poor regions (and its sectors) towards the affluent high-wage sectors of the high-income regions.

Environmental damage is mainly modeled in the form of gaseous pollution. Greenhouse gas emissions (measured as CO_2 equivalents) are thought to be the end result of four sets of economic activities: (1) the combustion of fossil fuels to produce aggregate energy; (2) industrial processes used for the production of iron, steel, chemicals, and cement; (3) agricultural processes (mainly methane); and (4) household consumption and waste.

Submodeling of environmental pollution in the CGE apparatus recognizes these sources using technological parameters derived from the CO_2 eq. emissions inventory published by TurkStat. A bird's-eye view of these relationships is portrayed in Fig. 4.1. Pollution is documented across the

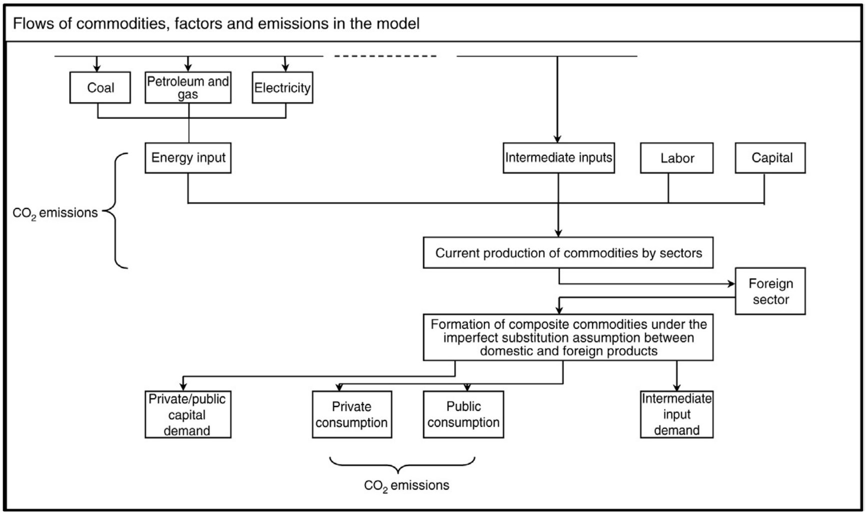

Figure 4.1 ***Structure of emission flow under general equilibrium.***

energy-production activities and industrial and agricultural processes within the given production technologies. Waste is generated through consumption activities of private households.

The CGE methodology accommodates these activities by selecting the free parameters to fit the algebraic equation system to the base-year equilibrium data, a procedure known as *calibration*. Calibration involves compilation of an annual dataset (in equilibrium) across its expenditures and revenues. Tabulated as a micro- and macrosystem of equilibrium relationships, this dataset is referred to as the social accounting matrix (SAM) (Pyatt and Round (1979) provide a seminal introduction to the SAM system of accounts). The model's algebraic specifications are then utilized to distill the parametric values including the share parameters on production and consumption, key shift variables of numerous functional forms, and policy rates (i.e., taxes and subsidies). The "calibrated" model must be able to generate the original dataset disclosed in the SAM without any further statistical inference. This solution is known as the "base year." Using a set of behavioral rules of capital accumulation and technical change alongside exogenous labor force (population) growth, dynamic CGE simulations set the stage for a *base path*.

The CGE exercises in this model will utilize the 2012 input–output (I/O) flow data published by TurkStat. Starting from the base year (2012), the algebraic system of general equilibrium will be accommodated by calibrating the free parameters and shift variables as noted above.

The algebraic equations are introduced in a more formal format in the following section, which documents our data in the SAM system.

4.2 ALGEBRAIC STRUCTURE OF THE CGE MODEL

The model is composed of 17 production sectors spanning two regionalied bodies for the Turkish economy (*high* versus *low income*), a representative private household to carry out savings-consumption decisions, a government to implement public policies towards environmental abatement, and a "rest of the world" account to resolve the balance of payment transactions. Antecedents of the model rest on the seminal contributions of the CGE analyses on gaseous pollutants, energy utilization, and climate change economics for Turkey as shown in Acar and Yeldan (2016), Kumbaroglu (2003), Lise (2006), Akin-Ölçüm and Yeldan (2013), Şahin (2004), Telli et al. (2008), and Vural (2009); however, it should be noted that these studies were based on *national* aggregates. Given the official focus on regional investment and subsidization in Turkey, it is pertinent to work with a regional diversification. Such an exercise was implemented in Yeldan et al. (2013, 2014) in the context of duality of *middle income* versus *poverty traps* of the Turkish socioeconomic structure. This procedure is followed here for the compilation of regional-level data. More details of this procedure are given Section 4.2.3.

4.2.1 Commodity Structure and Regional Commodity Markets

In the absence of official *regional* I/O data for this model, the procedure of Yeldan et al. (2013, 2014) in setting a regional differentiation of the components of final demand was followed. Aggregate national accounts were decomposed into two regions: *high and low income*. This decomposition was used to generate a "final goods aggregate" of macroeconomic demand based on product differentiation and imperfect substitution, as in Armington (1969). The *Armingtonian composite* goods structure was utilized in setting the demand for the domestically produced goods versus imports of total absorption ($Q^S + M - X$). This notion was extended across regions, and the sectorial domestically produced goods aggregate (DC_i) was decomposed into the regional sources (as shown in Eq. (4.1)):

$$\mathrm{DC}_i = \mathrm{BC}_i\left[\gamma_i \mathrm{DC}_{i,\mathrm{RH}}^{-\rho_i} + (1-\gamma_i)\mathrm{DC}_{i,\mathrm{RL}}^{-\rho_i}\right]^{-1/\rho_i} \tag{4.1}$$

Thus $\mathrm{DC}_{i,R}$ (R = RH, RL) forms the aggregate domestic goods along an imperfect substitution specification of the Armington aggregate. The aggregate composite goods (absorption) were then given as a constant elasticity of substitution (CES) aggregation of imports (M_i) and DC_i (as shown in Eq. (4.2)):

$$CC_i = AC_i\left[\delta i DC_i^{-\phi_i} + (1-\delta_i)M_i^{-\phi_i}\right]^{-1/\phi_i} \tag{4.2}$$

Production activities were differentiated using regional data on production, employment, and exports.

4.2.2 Production Technology and Gaseous Pollutants

The production of gross output was modeled as a multistage activity of nested production function in each sector (i). At the top-stage gross output of region R, sector i was given by an expanded CES functional of the form:

$$Q_{i,R}^S = A_{i,R}\left[\gamma VA_{i,R}^{-\beta_i} + (1-\gamma_i)E_{i,R}^{-\beta_i}\right]^{-1/\beta_i} \tag{4.3}$$

In Eq. (4.3), A denotes exogenously determined total factor productivity (TFP), VA is the sectorial value added, and E is the energy aggregate input. Thus the aggregate output supply brings together the value-added component with the energy input requirement of the sector. The energy aggregate input was assumed to be utilized in the sectorial gross output production only imperfectly substituting the value-added activities. This elasticity of substitution is given as $\left(\frac{1}{1-\beta}\right)$.

In Eq. (4.4) VA is obtained via the conventional Cobb–Douglas specification of the two major factors of production; capital (K) and labor aggregate (LA).

$$VA_{i,R} = K_{i,R}^{\lambda_K} LA_{i,R}^{\lambda_{LA}} \tag{4.4}$$

Here LA is the labor aggregate of two types of labor recognized in the model: formal and informal (vulnerable). Eq. (4.5) shows a composition of labor aggregates where formal and informal labor types substitute each other, albeit imperfectly, along CES formulations.

$$LA_{i,R} = A_{i,R}^L\left[\Lambda_{i,R} LF_{i,R}^{-\eta_{i,R}} + (1-\Lambda_{i,R})LI_{i,R}^{-\eta_{i,R}}\right]^{-1/\eta_{i,R}} \tag{4.5}$$

Each sector uses intermediate inputs ($IN_{j,i}$) derived from the I/O data. In Eq. (4.6) the variable E denotes the energy composite aggregate comprised of three environmentally sensitive activities of energy generation: coal (CO), petroleum and gas (PG), and electricity (EL). At the lower end of the two-stage characterization of sectorial output, this energy composite is determined by a CES function of its components:

$$E_{i,R} = A^{E}_{i,R}\left[\varphi_{\mathrm{CO},i,R}\mathrm{IN}^{-\rho_{i,R}}_{\mathrm{CO},i,R} + \varphi_{\mathrm{PG},i,R}\mathrm{IN}^{-\rho_{i,R}}_{\mathrm{PG},i,R} + \varphi_{\mathrm{EL},i,R}\mathrm{IN}^{-\rho_{i,R}}_{\mathrm{EL},i,R}\right]^{-1/\rho_{i,R}} \quad (4.6)$$

Under the given energy production technology, the optimum mix of inputs of CO, PG, and EL is determined by equating their marginal rate of technical substitution to their respective (input) prices, as affected by possible fiscal policy:

$$\frac{\mathrm{IN}_{\mathrm{CO},i,R}}{\mathrm{IN}_{\mathrm{EL},i,R}} = \left[\left(\frac{\varphi_{\mathrm{CO},i,R}}{1-\varphi_{\mathrm{CO},i,R}-\varphi_{\mathrm{PG},i,R}}\right)\left(\frac{P_{\mathrm{EL},i,R}}{\left(1+t^{\mathrm{ENV}}_{\mathrm{CO},i,R}\right)P_{\mathrm{CO},i,R}}\right)\right]^{\sigma_{i,R}} \quad (4.7)$$

$$\frac{\mathrm{IN}_{\mathrm{PG},i,R}}{\mathrm{IN}_{\mathrm{EL},i,R}} = \left[\left(\frac{\varphi_{\mathrm{PG},i,R}}{1-\varphi_{\mathrm{CO},i,R}-\varphi_{\mathrm{PG},i,R}}\right)\left(\frac{P_{\mathrm{EL},i,R}}{\left(1+t^{\mathrm{ENV}}_{\mathrm{PG},i,R}\right)P_{\mathrm{PG},i,R}}\right)\right]^{\sigma_{i,R}} \quad (4.8)$$

In Eqs. (4.7) and (4.8) t^{ENV} is the relevant tax instrument on the pollutant activity and σ is the elasticity of substitution with $\sigma = 1/(1 + \rho)$.

Sectorial demands for capital and labor follow the conventional optimization rules for equating marginal products with their respective input prices. The production technology for value added in Eq. (4.4) is of constant returns, thus Eq. (4.9) is used:

$$\lambda_{K,i,R} + \lambda_{\mathrm{LA},i,R} = 1 \quad (4.9)$$

The aggregate CO_2 emissions were captured in each sector (and region) from three origins: primary energy combustion (EE), secondary energy combustion (SE), and industrial processes (IND). In this specification, SE was due to the utilization of refined petroleum (RP), and emissions from IND were derived exclusively from iron and steel (IS), chemicals (CH), and cement (CE). The aggregate energy material balance data were used to map each sector's CO_2 emissions to these major sources using the summary in Table 4.1.

Distinct mechanisms were specified depending on the source of origin of the gaseous CO_2 eq. emissions. Emissions from EE activities were captured using Eq. (4.10), and emissions from SE of RP were captured using Eq. (4.11).

$$\mathrm{CO}^{j,i,R}_{2\mathrm{EE}} = \varepsilon_{j,i,R}\; a_{j,i,R}\; Q^{S}_{j,i,R} \quad (4.10)$$

$$\mathrm{CO}^{\mathrm{RP},i,R}_{2\mathrm{SE}} = z_{\mathrm{RP},i,R}\; a_{\mathrm{RP},i,R}\; Q^{S}_{\mathrm{RP},i,R} \quad (4.11)$$

Table 4.1 Distribution of CO_2 emissions from sectoral production activities by their source of origin

Abbreviations	Sectoral producers	Industrial processes	Primary energy utilization	Secondary energy utilization
AG	Agriculture	0.00	0.00	1.00
CO	Coal	0.00	0.30	0.70
PG	Crude oil and natural gas	0.00	0.80	0.20
PE	Refined petroleum	0.00	0.88	0.12
CE	Cement	0.66	0.16	0.18
IS	Iron and steel	0.67	0.15	0.18
MW	Machinery and white goods	0.00	0.00	1.00
ET	Electronics	0.00	0.75	0.25
AU	Auto industry	0.00	0.30	0.70
EL	Electricity production	0.00	1.00	0.00
CN	Construction	0.00	0.00	1.00
OE	Other economy	0.00	0.40	0.60

Source: Adopted from Energy Balances Tables, Min of Energy, and Natural Resources.

The parameter $\varepsilon_{j,i,R}$ in Eq. (4.10) summarizes the energy use coefficients (calibrated from the material energy balances tables) to set the composition of emissions from primary energy via the combustion of CO and PG in each sector. The $z_{\mathrm{RP},i,R}$ parameter in Eq. (4.11) similarly represents the emission coefficient due to the combustion of RP. The traditional I/O coefficient, $a_{j,i} = \frac{\mathrm{IN}_{j,i}}{Q_i^S}$, is responsive to price signals via optimizating costs, given technology (4.3). This is in contrast to traditional CGE analyses where $a_{j,i}$ is typically regarded as fixed, as in a Leontieff technology.

Emissions from IND were recognized from IS, CH, and CE. These emissions were regarded as proportional to their respective real output (as shown in Eq. (4.12):

$$\mathrm{CO}_{2i,R}^{IND} = \eta_{i,R} Q_{i,R}^{S} \quad i \in \{\mathrm{IS}, \mathrm{CH}, \mathrm{CE}\} \tag{4.12}$$

Emissions from agricultural processes were similarly set proportionally to agricultural gross outputs. Emissions of non-CO_2 gasses (CH_4, F, and NO_2) were set proportionally to the EE activities. Thus CO_2 eq. emissions of CH_4 were calculated as shown in Eq. (4.13) and CH_4 from waste was calculated as per Eq. (4.14).

$$\mathrm{CO}_{2\mathrm{CH}_4}^{j,i,R} = \varepsilon_{j,i,R}\ a_{j,i,R}\ Q_{i,R}^{S} \quad \text{for } j = \{\mathrm{CO},\mathrm{PG}\} \tag{4.13}$$

$$\mathrm{CO}_{2\mathrm{WST}}^{j,i,R} = \varpi_{j,i,R}\ Q_{i,R}^{S} \tag{4.14}$$

Household demand for energy generates an additional source of CO_2 eq. emissions. This was regarded as proportional to the household consumption of basic fuels (CO and RP) and calculated as in Eq. (4.15):

$$\mathrm{CO}_2^{\mathrm{HH}} = \sum_{i\in \mathrm{CO,RP}} K_i C_i^D \tag{4.15}$$

Aggregate CO_2 eq. emissions were calcualted as the sum of each of these sources (as shown in Eq. (4.16)):

$$\begin{aligned}\mathrm{CO}_2^{\mathrm{TOT}} = \sum_{j,i,R}\left(\mathrm{CO}_{2\,j,i,R}^{\mathrm{EE}} + \mathrm{CO}_{2\,j,i,R}^{\mathrm{SE}} + \mathrm{CO}_{2\,j,i,R}^{\mathrm{CH}_4} + \mathrm{CO}_{2\,j,i,R}^{\mathrm{WST}} +\right) \\ + \sum_{i\in \mathrm{IS,CE}} \mathrm{CO}_{2\,i,R}^{\mathrm{IND}} + \sum_{R} \mathrm{CO}_{2\,R}^{\mathrm{AGR}} + \mathrm{CO}_2^{\mathrm{HH}}\end{aligned} \tag{4.16}$$

4.2.3 Labor Markets, Income Generation, and General Equilibrium

The model distinguishes two types of labor: urban (formal) and informal. The formal wage rate is fixed and the formal labor market adjusts with unemployment in each period. The flexibility of the real wage in the informal labor market is characterized by the extent of fragmentation across the dualistic labor market in the Turkish economy. Data from different sectors and labor types were compiled from various TurkStat data sources. TurkStat provides sectoral labor employment data at the Nace Rev. 2 four-digit level, and regional formal–informal employment disaggregation data for the major sectors (i.e., agriculture, industry, and services) at the NUTS-2 level. The comprehensive treatment of both datasets makes it possible to approximate the sectoral formal and informal employment figures for both regions. In addition, the household labor force surveys (HLFS) from TurkStat were also used to determine the sectoral formal and informal wage ratios for the Nace Rev. 2, level 1. Hence total employment and total payments were obtained for each labor category in each region to enable calibration of the necessary parameters of the labor market.

The formal labor market was hypothesized to clear by quantity adjustments on employment (as shown in Eq. (4.17)):

$$U_{\mathrm{LF},R} = L_{\mathrm{LF},R}^{S} - \sum_i \mathrm{LF}_{i,R}^{D} \tag{4.17}$$

Conversely, the informal or vulnerable labor market operates with fully flexible wages. The low level of informal wages is a symptomatic proxy for poverty in the informal labor market.

The regional labor markets have been linked by migration over time. This is based on (expected) wage differences between high- and low-income Turkey, and is driven along the classic Harris and Todaro (1970) specification. Given the migrants from each labor type (l):

$$\mathrm{MIG}_l(t) = \mu_l \left[\frac{\left(E\left[W_{l,\mathrm{RH}} \right] - W_{l,\mathrm{RL}} \right)}{W_{l,\mathrm{RL}}} \right] L^S_{l.\mathrm{RL}} \tag{4.18}$$

where $E[W_{l,\mathrm{RH}}]$ is the expected wage rate of labor type l (=LF, LI) in the high-income region and μ_l is a calibration parameter (as shown in Eq. (4.18)).

Given that $\mathrm{MIG}_l(t)$ is based on wage expectations from high-income regions, labor supplies evolve according to Eq. (4.19):

$$\begin{aligned} L^S_{l,\mathrm{RL}}(t+1) &= \left(1 + n_{l,\mathrm{RL}}\right) L^S_{l,\mathrm{RL}}(t) - \mathrm{MIG}_l(t) \\ L^S_{l,\mathrm{RH}}(t+1) &= \left(1 + n_{l,\mathrm{RH}}\right) L^S_{l,\mathrm{RH}}(t) + \mathrm{MIG}_l(t) \end{aligned} \tag{4.19}$$

Capital stocks evolve given the net of depreciation of fixed investments. The allocation of aggregate net investment funds to specific sectors (investment by destination sector) is accomplished through the calculation of regional profitability. Given sectorial profit rates ($r_{i,R}$) across regions, and the economy-wide average profit rate (r^{AVG}), sectorial investment allocations ($\Delta K_{i,R}(t+1)$) are given by the simple rule in Eq. (4.20):

$$\Delta K_{i,R}(t+1) = \Pi_{i,R} + \Pi_{i,R} \left[\frac{r_{i,R-r^{\mathrm{AVG}}}}{r_{i,R}} \right] \tag{4.20}$$

where $\Pi_{i,R}$ is the share of aggregate profits in sector, i, and region, R. This sets the allocation of physical investments to be reused via profit differences in the second part of the equation.

Private household income is composed of wage incomes from labor and remittances of profits from the enterprise sector. Public sector revenues comprise tax revenues (i.e., from wage and capital incomes) and nontaxation sources of income (i.e., from various exogenous flows). The income flow of the public sector is further augmented by indirect taxes and environmental taxes. This model closely follows the fiscal budget constraints. Given public earnings, the government's "transfer expenditures to households" were adjusted endogenously to sustain other components of public demand (i.e., public investment and consumption expenditure) as fixed ratios to the national income.

General equilibrium of the system was obtained via endogenous solutions on prices, wage rates, and the exchange rate. Informal wage rates across regions clear regional labor markets. The balance of payments is cleared through flexible adjustments on the real exchange rate (the ratio of the price of domestic goods to imports in the CGE folklore), while the *nominal* conversion factor across domestic and world prices serves as the *numeraire* of the system.

The model was solved iteratively by updating the annual "solutions" of the model to 2030. Aggregate output supplies grew through three channels: (1) the exogenous growth of labor supplies; (2) investments on physical capital net of depreciation; and (3) TFP growth, which in turn was regarded as exogenous. Capital stocks across regions and sectors were augmented with net investments in each period. Regional labor supplies were increased exogenously by population growth and migration (see Eq. (4.18)). TFP rates were updated in a Hicks-neutral manner, and formal real wage rates were updated by the cost of living index (endogenously solved).

4.3 DATA SOURCES AND CALIBRATION METHODOLOGY

4.3.1 Construction of the Regional Social Accounting Database

Regional I/O data are not available in Turkey, and the most recent I/O data was tabulated in 2012 by TurkStat. Given the lack of official regional data, regional economic activities were differentiated based on the standard tools of CGE applications. The SAM for 2012 (published by TurkStat) was generated using national income data on macroaggregates. Labor remunerations were obtained from the International Labor Organization (ILO) and TurkStat HLFS data. The aggregated I/O table for 2012 is displayed in Table 4.2.

Following production of the regional SAM (available upon request), the national macroaggregates were decomposed via the shares of gross regional value added. Based on the differentiation of *level 2* NACE-1 data, 7 regions

Table 4.2 Turkey: I/O flow, 2012 (thousand TRY, at basic prices)

(a)

	AG	CO	PG-OM	PE	CH	CE	IS	PA	FD
AG: Agriculture	29,438,100.0	78,743.9	54,546.9	342.8	627,218.4	29,432.2	1,626.7	329,948.4	56,673,900.0
CO: Coal	241,156.8	1,812,815.0	46,806.7	0.0	51,800.0	1,212,684.0	9,904.6	5,596.6	11,085.5
PG-OM: Crude petrol, gas, and other mining	210,906.6	7,552.8	79,146.8	31,949,853.4	2,421,500.3	6,996,719.6	9,773,476.0	262,898.8	828,376.9
PE: Petroleum products and chemicals	4,463,786.0	482,505.4	1,413,983.2	896,789.5	881,275.0	1,805,806.0	404,557.2	103,165.7	655,855.6
CH: Chemicals	8,943,774.0	149,786.5	518,011.9	34,323.7	39,930,000.0	2,138,284.0	2,203,785.0	3,010,425.0	5,654,674.0
CE: Cement	131,181.1	29,774.1	176,995.1	959.4	638,264.6	6,899,405.0	404,325.4	4,348.3	551,646.0
IS: Iron and steel	6,189.1	176,973.1	189,257.0	15,557.3	628,560.3	402,435.3	22,077,700.0	128,280.6	110,110.1
PA: Paper and print	112,492.8	1,145.2	7,790.0	33,263.3	1,001,410.0	532,824.6	236,644.8	7,671,507.0	2,493,897.0
FD: Food processing	6,367,557.0	1,287.7	35,888.5	8,423.0	163,603.6	35,275.8	15,534.0	120,936.4	23,837,200.0
TE: Textiles and clothing	109,045.8	34,191.3	71,756.1	3,727.0	660,675.7	191,847.4	60,557.2	440,838.4	310,247.9
MW: Machinery and white goods	191,484.4	95,966.7	286,033.5	28,047.8	750,545.5	201,658.7	721,510.2	55,299.5	711,785.0
ET: Electronics	71,891.1	57,314.0	29,347.2	8,154.9	130,570.8	137,281.9	33,310.1	43,219.4	116,673.8
AU: Automotive	265,689.5	452.6	9,533.1	24.4	1,025.7	17,526.2	0.0	1,466.0	533.3
EL: Electricity	902,509.1	245,169.5	734,655.4	26,902.8	2,034,290.0	2,554,476.0	4,387,732.0	528,733.6	1,835,289.0
CN: Construction	364,064.3	41,899.8	51,341.5	2,076.5	226,323.2	85,032.7	254,640.8	44,775.1	350,386.1
TR: Transportation	2,578,411.0	245,772.3	1,498,623.4	862,801.1	3,252,146.0	1,882,996.0	4,523,179.0	1,073,265.0	7,004,565.0
OE: Other economy	7,502,169.0	619,327.6	3,218,933.1	1,689,206.0	11,925,900.0	6,085,395.0	31,673,200.0	4,342,108.0	20,183,500.0
Totals									
Compensation of employees	3,194,349.0	2,931,077.0	2,350,736.8	490,184.0	9,417,064.0	6,014,431.0	4,865,445.0	2,898,136.0	13,409,100.0
Gross payments to capital	114,385,806.7	7,537,819.5	6,476,128.0	4,300,537.1	26,692,027.6	13,138,833.8	17,346,494.5	6,496,242.2	44,601,389.6
Net taxes	−409,801.0	392,980.3	1,013,682.7	5,347,046.8	4,198,528.4	1,941,986.2	4,545,101.4	993,550.4	1,464,525.4
Total value added (at market prices)	117,170,354.7	10,861,876.9	9,840,547.5	10,137,767.9	40,307,620.0	21,095,251.0	26,757,040.9	10,387,928.7	59,475,015.0
Total production Exp	179,070,762.3	14,942,554.4	18,263,196.8	45,698,220.9	105,632,729.2	52,304,331.3	103,538,723.8	28,554,740.4	180,804,740.2

(b)

	Private consumption expenditure	Government consumption expenditure	Gross fixed capital formation
AG: Agriculture	70,943,213.9	0.0	10,984,631.9
CO: Coal	6,163,732.6	0.0	523,308.1
PG-OM: Crude petrol, gas, and other mining	0.0	0.0	0.0
PE: Petroleum products and chemicals	8,170,146.6	0.0	0.0
CH: Chemicals	15,741,170.2	14,653,682.7	276,625.2
CE: Cement	2,852,345.6	0.0	801,269.3
IS: Iron and steel	0.0	0.0	0.0
PA: Paper and print	4,908,205.9	0.0	0.0
FD: Food processing	116,848,603.9	0.0	0.0
TE: Textiles and clothing	55,215,191.4	0.0	372,594.0
MW: Machinery and white goods	3,885,275.6	0.0	59,032,407.9
ET: Electronics	17,821,133.8	0.0	22,081,839.7
AU: Automotive	17,253,690.8	0.0	21,843,085.3
EL: Electricity	24,604,258.9	0.0	0.0
CN: Construction	2,059,032.5	8,665.4	241,179,412.4
TR: Transportation	101,554,459.4	913,471.0	6,702,682.1
OE: Other economy	531,047,583.0	207,825,882.9	80,484,489.1
	979,068,044.0	**223,401,702.0**	**444,282,345.0**

TE	MW	ET	AU	EL	CN	TR	OE	Total intermediate exp
5,963,512.0	6,837.4	7,643.8	13.3	218.1	114,145.0	14,755.5	6,983,250.0	100,324,234.4
39,119.1	10,533.4	2,043.2	17,471.2	2,892,929.0	150,131.4	369,767.5	3,420,575.0	10,294,419.0
1,049,632.2	189,652.8	131,751.2	132,587.2	25,263,600.0	4,752,312.0	48,579.8	342,494.6	84,441,041.0
393,888.5	392,764.6	434,782.5	104,590.8	402,526.5	4,985,364.0	27,820,300.0	15,290,800.0	60,932,740.5
11,970,200.0	2,063,803.0	3,963,530.0	2,521,522.0	74,998.0	9,011,344.0	2,505,050.0	19,249,500.0	113,943,011.0
34,853.0	486,955.6	395,805.1	499,281.2	130,407.6	26,354,700.0	873,664.8	6,311,453.0	43,924,019.4
35,588.7	23,231,400.0	9,206,265.0	7,382,780.0	71,908.0	25,127,300.0	214,117.1	6,893,704.0	95,898,125.6
1,138,633.0	375,728.6	416,025.6	91,823.0	76,001.1	158,535.2	493,570.0	12,457,800.0	27,299,091.1
532,843.7	53,060.9	22,277.6	9,271.1	20,740.3	112,564.6	192,790.3	22,277,700.0	53,806,954.4
54,879,800.0	194,564.3	106,494.7	360,412.2	4,587.5	150,869.4	213,276.3	6,420,095.0	64,212,986.2
411,298.9	8,533,914.0	2,544,749.0	4,400,737.0	13,924.3	14,862,000.0	1,043,107.0	8,283,650.0	43,135,711.5
249,493.4	1,383,245.0	8,789,359.0	2,310,104.0	523,752.9	5,576,912.0	232,564.4	9,502,252.0	29,195,445.9
20.5	908,353.4	32,064.5	14,162,600.0	152.1	26,964.7	1,079,149.0	2,930,046.0	19,435,601.0
3,103,648.0	1,151,517.0	400,417.4	472,991.9	60,459,600.0	428,257.7	441,051.6	18,662,500.0	98,369,741.0
191,751.7	262,073.7	61,717.8	42,641.2	409,542.4	47,242,300.0	423,232.1	16,689,700.0	66,743,498.9
3,072,462.0	3,406,436.0	1,669,822.0	1,988,092.0	519,813.8	5,737,816.0	40,418,700.0	33,450,400.0	113,185,300.6
16,494,100.0	9,727,960.0	7,780,041.0	7,605,626.0	4,763,437.0	35,747,500.0	38,953,100.0	257,395,000.0	465,706,502.7
								1,490,848,424.1
19,660,200.0	11,817,200.0	5,591,437.0	5,157,910.0	3,486,053.0	28,437,900.0	17,995,900.0	300,861,000.0	438,578,122.8
40,845,650.7	25,534,769.8	11,112,743.6	11,235,858.0	18,247,251.3	96,009,108.4	106,232,907.8	495,482,442.8	1,045,676,011.6
2,564,477.7	2,551,131.5	2,102,840.6	2,389,320.9	5,542,117.9	7,227,473.0	16,871,035.3	26,681,983.0	85,417,980.6
63,070,328.4	39,903,101.3	18,807,021.2	18,783,088.9	27,275,422.2	131,674,481.4	141,099,843.1	823,025,425.8	**1,569,672,115.0**
162,631,173.1	92,281,901.0	54,771,810.6	60,885,633.0	122,903,560.8	312,213,497.4	256,436,618.5	1,269,586,345.4	**3,060,520,539.1**

Exports	Imports (−)	Total exp on value added	Total expenditure
10,924,038.1	14,105,355.9	78,746,527.9	179,070,762.3
9,371.6	2,048,276.9	4,648,135.4	14,942,554.4
6,053,357.1	72,231,201.2	−66,177,844.1	18,263,196.8
14,094,423.9	37,499,090.1	−15,234,519.6	45,698,220.9
27,660,558.7	66,642,318.8	−8,310,281.9	105,632,729.2
7,875,980.9	3,149,283.8	8,380,311.9	52,304,331.3
53,569,058.7	45,928,460.5	7,640,598.3	103,538,723.8
3,267,467.6	6,920,024.1	1,255,649.3	28,554,740.4
20,597,168.8	10,447,987.0	126,997,785.7	180,804,740.2
62,494,817.1	19,664,415.6	98,418,186.9	162,631,173.1
31,415,579.0	45,187,072.9	49,146,189.5	92,281,901.0
25,981,041.8	40,307,650.6	25,576,364.7	54,771,810.6
32,455,691.2	30,102,435.3	41,450,032.0	60,885,633.0
393,883.6	464,322.8	24,533,819.7	122,903,560.8
2,843,140.2	620,252.0	245,469,998.5	312,213,497.4
35,259,722.2	1,179,016.8	143,251,317.9	256,436,618.5
36,604,740.5	52,082,852.7	803,879,842.7	1,269,586,345.4
371,500,041.0	**448,580,017.0**	**1,569,672,115.0**	**3,060,520,539.1**

Table 4.3 Economic indicators across regions (million TRY, 2012)

Region	Gross regional value added	Employment of formal labor (thousand persons)	Employment of informal labor (thousand persons)	Regional exports	Taxes on production and employment
High-income[a]	1,099,689.6	11,054.9	6,111.7	295,561.4	138,472.5
Low-income[b]	296,848.9	3,517.8	4,136.6	75,938.6	34,661.1

[a] High-income regions: TR10, TR21, TR31, TR41, TR42, TR51, and TR61.
[b] Low-income regions: TR62, TR63, TR71, TR72, TR81, TR82, TR83, TR90, TR52, TR53, TR32, TR33, TR22, TRA1, TRB1, TRB2, TRC1, TRC2, and TRC3.
Source: Authors calculations from TurkStat, Regional National Income Statistics.

were distinguished as "high income" and 19 regions were classified as "low income." Data revealed that the low-income regions host approximately 60% of the total 73.7 million population, and produce around 32% of the aggregate value added. The remaining 68% of the aggregate value added originated in the *high-income* region. Further specifics of the regional macrodata are provided in Table 4.3.

The SAM tabulates the microlevel I/O data with the aggregate macrodata on public sector balances and resolves the saving–investment equilibrium. The latter discloses a current account deficit (foreign savings) of TRY 86,135.6 million (roughly 6.5% to the GDP). *High-* versus *low-income* Turkey yield the production activities, while components of aggregate national demand were revealed using imperfect substitution in demand, and were calibrated through standard methods of the Armingtonian composite system.

This procedure was definitely a poor alternative to more direct approaches based on regionally-differentiated production structures. However, this requires *regional* I/O data and regional material balances. In the absence of official or independent regional data, the Armingtonian imperfect substitutability framework based on cost optimization was utilized.

It is of note that the specification here was designed to only capture the regionally-differentiated component of (investment) subsidization. Therefore it should not be regarded as a detailed structural characterization of the dualistic (fragmented) patterns of production attributable to the Turkish economy, which is an issue beyond the scope of this paper.

4.3.2 Parametrization of Gaseous Pollutants

A total of 447.45 million tons of CO_2 eq. were reportedly released in Turkey in 2012. TurkStat data distinguished this sum into four sources (million tons): energy combustion (264.8), industrial processes (41.8), agricultural processes (21.2), and waste (56.5). Using a different level of aggregation, emissions of CO_2, CH_4, N_2O, and F-gasses accounted for 363.1, 58.0, 21.1, and 5.2 million tons of this total, respectively.

To direct these data into sectorial sources of origin, TurkStat data reported to the UNFCCC inventory system was used. Where possible, original data on greenhouse gas source and sink categories were used to make direct connections between the sectors in the official dataset and the sectors distinguished in this model (i.e., agriculture, refined petroleum, cement, iron and steel, and electricity). The remaining unaccounted CO_2 emissions were allocated to the aggregate using the share of the sectorial intermediate input demand. This exercise yielded CO_2 eq. emissions across production sectors and other activities as shown in Table 4.4.

Data in Table 4.4 was initially used to calculate the total sectorial emissions, CO_{2i}^{TOT}. This sum was decomposed into three main sources of origin: emissions from EE, SE, and IND. This was performed using Table 4.1. Assuming $\pi_{s,i}$ ($s \in$EE,SE,IND) is a typical element of Table 4.1, then:

$$\mathrm{CO}_{2S,i} = \pi_{S,i}.\mathrm{CO}_{2i}^{\mathrm{TOT}}$$

The coefficient $z_{\mathrm{RP},i}$ was subsequently calibrated by:

$$z_{\mathrm{RP},i} = \frac{\mathrm{CO}_{2\mathrm{RP},i}^{\mathrm{SE}}}{\mathrm{IN}_{\mathrm{RP},i}}$$

For distinguishing this aggregate into the regional activities, regional shares of sectorial output were used. The source of CO_2 eq. emissions ideally ought to be used for regions; however, ad hoc specifications were not made due to the absence of precise regional data measurements. A similar procedure was followed to determine the EE sources of CO_2 eq. emissions across sectors (for $j \in$CO and PG) and $CO_{2j,i}^{EE}$ was found from data displayed in Table 4.4 using the $\varepsilon_{j,i}$ for $j \in$CO and PG.

4.3.3 Calibration of the Labor Markets

Two types of labor were distinguished in the model: formal and informal. The characterization was based on the ILOs definition of informal employ-

Table 4.4 Aggregate CO_2 eq. emissions, 2012

Total CO_2 emissions from energy combustion (million tons)	**264.83**
AG: Agriculture	3.48
CO: Coal	2.58
PG: Oil and gas	
MI: Other mining	
PE: Refined petroleum	4.66
CH: Chemicals	5.40
CE: Cement	27.06
IS: Iron and steel	7.98
PA: Paper and print	1.22
FD: Food processing	2.98
TE: Textiles, clothing	0.02
MW: Machinery, white Goods	0.06
ET: Electronics	2.34
AU: Automotive	0.00
EL: Electricity	119.36
CN: Construction	1.83
TR: Transportation	64.55
OE: Other economy	21.30
Total CO_2 emissions by households	**56.48**
Total CO_2 emissions from industrial processes	**41.81**
Cement	30.28
Iron and Steel	9.90
Chemicals	1.63
Total GHG emissions (CO_2 eq.)	**84.33**
CH_4 from industrial production	58.03
NO_2 from agricultural processes	21.12
F gasses from waste	5.18
Total CO_2 eq.	**447.45**

ment, which is informal (unregistered employment that is under any social security coverage) + self-employed + unpaid family labor. Using this criteria, a total of 24,819 thousand workers was distributed across regions and sectors (using the HLFS TurkStat data). Table 4.5 shows parametrization of the labor markets.

The I/O wage and salary data is used to set the formal labor share in national income. Using this data, we used the formal and informal employment shares from the HLFS data to produce aggregate wage income data for the informal labor. Finally, the sectorial and regional wage remunerations across labor types were obtained using the sectorial income shares from the I/O table. All data is summarized in Table 4.5.

Table 4.5 Parameters of the labor market, 2012

				Labor employment (thousand workers)				Total wages (Million TRY, 2012)			
				High-income region		Low-income region		High-income region		Low-income region	
		Nace 2.0	Total labor	Formal labor	Informal labor	Formal labor	Informal labor	Formal labor	Informal labor	Formal labor	Informal labor
1	AG: Agriculture	A–01, 02, 03	6,097.000	692.000	2,493.000	307.211	2,606.789	1,195.328	1,090.099	208.377	700.545
2	CO: Coal	B–05	51.024	34.925	4.939	9.778	1.383	2,328.745	93.190	493.105	16.037
3	PG+OM: Petroleum gas and other mining	B–06 + 07 + 08	79.884	54.679	7.732	15.308	2.165	1,843.365	99.038	395.472	12.862
5	PE: Refined petroleum	C–19	10.042	6.874	0.972	1.924	0.272	366.157	23.386	97.604	3.037
6	CH: Chemicals	C–20 + 21 + 22	365.705	216.649	69.065	47.157	32.834	7,085.441	876.576	1,261.741	193.306
7	CE: Cement	C–23	294.571	174.508	55.631	37.984	26.448	4,525.285	559.846	805.841	123.460
8	IS: Iron and steel	C–24	154.330	91.428	29.146	19.900	13.856	3,660.782	452.894	651.894	99.874
9	PA: Paper and print	C–17 + 18	148.416	87.924	28.029	19.138	13.325	2,180.570	269.769	388.305	59.491
10	FD: Food processing	C–10 + 11 + 12	594.080	351.942	112.195	76.605	53.338	10,089.067	1,248.170	1,796.612	275.252
11	TE: Textiles and clothing	C–13 + 14 + 15	1,267.238	750.731	239.324	163.407	113.777	14,792.422	1,830.046	2,634.163	403.569
12	MW: Machinery and white goods	C–25 + 28	647.672	383.690	122.316	83.516	58.150	8,891.314	1,099.990	1,583.322	242.574

(Continued)

Table 4.5 Parameters of the labor market, 2012 (*Cont.*)

				Labor employment (thousand workers)				Total wages (Million TRY, 2012)			
				High-income region		Low-income region		High-income region		Low-income region	
		Nace 2.0	Total labor	Formal labor	Informal labor	Formal labor	Informal labor	Formal labor	Informal labor	Formal labor	Informal labor
13	ET: Electronics	C–26 + 27	208.502	123.520	39.376	26.886	18.720	4,207.022	520.472	749.166	114.777
14	AU: Automotive	C–29	208.398	123.458	39.357	26.872	18.711	3,880.834	480.118	691.080	105.878
15	EL: Electricity	D–35	218.000	129.146	41.170	28.111	19.573	2,933.647	81.741	434.085	36.580
16	CN: Construction	F	1,709.000	688.059	570.927	245.941	204.073	16,030.766	6,370.533	3,893.117	2,143.484
17	TR: Transportation	H–49 + 50 + 51 + 53	941.559	485.223	208.405	173.439	74.493	15,778.075	695.419	1,334.800	187.606
18	OE: Other economy	09 + 16 + 30 + 31 + 32 + 33 + 36 + 37 + 38 + 39 + 4 + 5 + 46 + 47 + 52 + I + J + M + N + P + Q + R + S	11,823.579	6,660.124	2,050.071	2,234.649	878.735	265,910.609	9,107.471	22,896.581	2,946.338
	Total		**24,819.000**	**11,054.878**	**6,111.655**	**3,517.826**	**4,136.641**	**365,699.429**	**24,898.757**	**40,315.266**	**7,664.670**

Source: Authors' calculations from TurkStat, Household Labor Force Surveys.

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