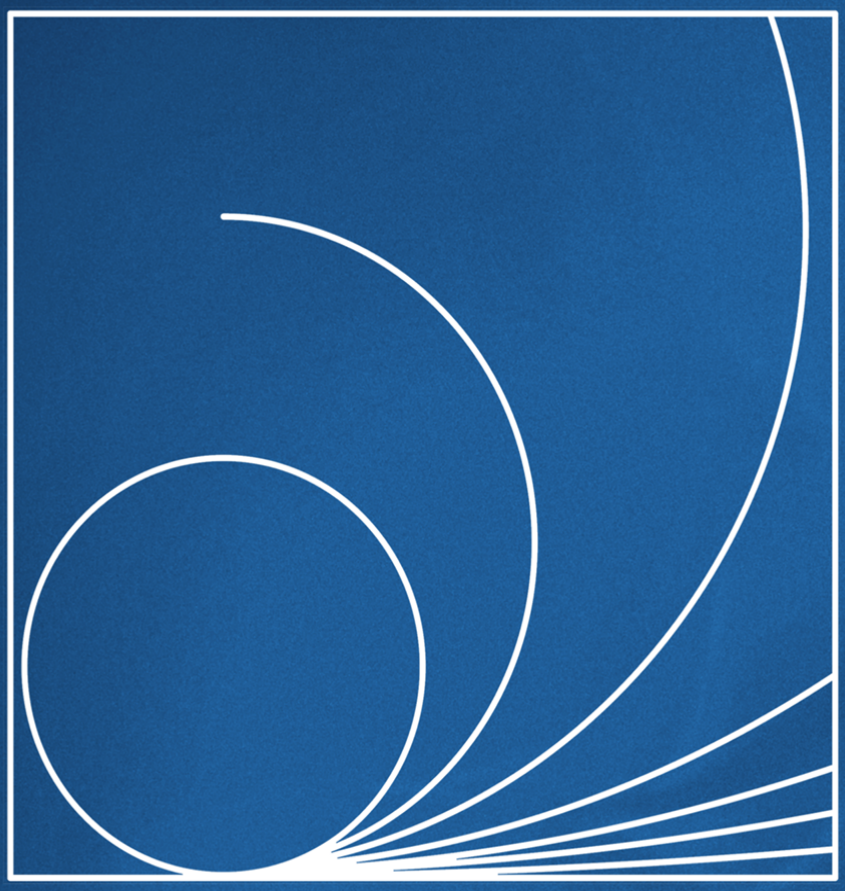

Economic, Trade, and Industry Implications of the Circular Economy Transition In Türkiye

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Introduction

Economic and population growth over the past 50 years have increased global natural resource use to levels that severely affect human well-being. Global demand for material resources has increased more than three times over the past 50 years and could increase by almost 60 percent from 2020 levels by 2060, from 100 to 160 billion tons (UNEP 2024).[1] Already today resource extraction and use are key drivers of natural resource degradation, pollution, climate change, and biodiversity loss. For example, materials management, including the production, consumption, and disposal of materials, products, and infrastructure, contributes up to two-thirds of global greenhouse gas (GHG) emissions. Similarly, 90 percent of total biodiversity loss and water stress impacts and 33 percent of health effects of air pollution are directly linked to resource extraction and processing (UNEP 2019).[2] Ballooning resource consumption also has trade and security implications, raising concerns over potential future resource shocks and supply failures worldwide. As material extraction and use attain ever higher levels, so do the corresponding environmental, social, and economic impacts.

In Türkiye, as elsewhere, economic and population growth have been accompanied by increasing levels of material consumption and waste. Domestic extraction of natural resources increased from 558 million tons in 2000 to over 2 billion tons in 2021.[3] At the same time, domestic material consumption (DMC) increased from 630 million tons in 2000 to 980 million tons in 2021.[4] While the generation of Türkiye's municipal waste is below the average of the Organisation for Economic Co-operation and Development (OECD) and the recycling rates are increasing, a large share of municipal waste is sent to landfills. Even though recycling of municipal waste has increased from 13 percent in 2017 to 27.2 percent in 2021 and further to almost 35 percent in 2023,[5] the goal stated in the "Zero-Waste Initiative" (see below) is to reach 60 percent by 2035. Some 30.3 million tons of municipal waste was generated in a single year (2022) [6] compared to less than 60 million tons of recycled waste collected over seven years in 2017–2023, which indicates opportunities for further improvements in this important aspect of circularity. In terms of individual materials, a share of secondary steel production is significant (over 70 percent), while the recycling rate of plastics is less than 6 percent.[7]

The need to transition away from current 'linear' resource use patterns is conceptualized and promoted within the circular economy (CE) concept. In the linear 'take-make-use-dispose' economy, products generally become waste once they have reached the end of their useful life. The transition to a low-carbon and circular economy requires a change of approach aimed at decoupling natural resource extraction and use from economic output.[8] In the European Union (EU), the CE is defined as an economic system where the value of products, materials, and other resources in the economy is maintained for as long as possible, enhancing their efficient use in production and consumption, thereby reducing the environmental impact of their use and minimizing waste and the release of hazardous substances at all stages of their life cycle, including through the application of the waste hierarchy (EU

[1] UNEP (United Nations Environment Programme). 2024. "Global Resources Outlook 2024: Bend the Trend - Pathways to a Livable Planet as Resource Use Spikes." International Resource Panel. Nairobi, Kenya.
[2] UNEP (United Nations Environment Programme). 2019. "Global Resources Outlook 2019: Natural Resources for the Future We Want." International Resource Panel. Nairobi, Kenya.
[3] https://www.materialflows.net/visualisation-centre/country-profiles/.
[4] https://data-explorer.oecd.org/vis?lc=en&tm=Material%20resources&pg=0&snb=17&df[ds]=dsDisseminateFinalDMZ&df[id]=DSD_MATERIAL_RESOURCES%40DF_MATERIAL_RESOURCES&df[ag]=OECD.ENV.EPI&df[vs]=1.0&pd=2000%2C2021&dq=TUR.A.DMC.T.TOT&ly[cl]=TIME_PERIOD&to[TIME_PERh.
[5] Ministry of Environment, Urbanization and Climate Change. https://cygm.csb.gov.tr/sifir-atik-ile-geri-kazanim-orani-35e-ulasti.-haber-286897.
[6] Turkish Statistical Institute, https://data.tuik.gov.tr/Bulten/Index?p=Waste-Statistics-2022-49570&dil=2.
[7] Karasik, R. 2022. "Plastic Pollution Policy Country Profile: Turkey." Duke Nicholas Institute for Environmental Policy Solutions, Policy Brief. https://nicholasinstitute.duke.edu/sites/default/files/projects/Plastic-Pollution-Policy-Country-Profile-Turkey.pdf.
[8] Decoupling refers to a state of the economy that shows growth which is not accompanied by increases in environmental (for example, material use) pressures. Under *absolute decoupling,* the environmental pressures decline or stay stable over time. Under *relative decoupling,* the environmental pressures increase at a lower rate than the growth of the economy (for example, gross domestic product [GDP] growth rate).

2020).[9] However, getting there requires political commitment and long-term targets, as well as economic incentives and support for businesses and consumers to change course.

Türkiye recognizes that it must transition to a more 'circular' and material-efficient growth model. Türkiye launched its Zero-Waste Initiative in 2017 and the CE is flagged as a priority in the 2021 Economic Reform Program. Türkiye's ambitious goals include creating 100,000 new jobs in zero-waste management systems, achieving over US$2 billion savings by 2023, and reaching a recycling rate of municipal waste 60 percent by 2035. Türkiye has also ratified the Paris Agreement, developed the country's Nationally Determined Contribution (NDC), and announced the net zero emissions target by 2053. In addition, the Green Deal Action Plan of Türkiye was published in 2021 with the aim of establishing Türkiye's alignment with the European Green Deal, including on issues related to the green and circular economy. To complement the net zero emissions target and the objectives of the Green Deal Action Plan of Türkiye, in 2022, the government announced a multitude of decisions (217) taken by the Climate Council, contributing to the fight against the impacts of global warming and waste management. One decision, for example, involves the acceleration of separate waste disposal with a focus on recycling and the rejection of waste not pre-processed from disposal facilities. CE is also prominently featured in the Twelfth Development Plan (2024-2028), adopted in October 2023, which includes sector-specific objectives for the manufacturing, chemicals, electrical equipment, automotive, agriculture and food, energy, and construction. Currently, the government is finalizing a national CE Strategy and Action Plan.

Türkiye's membership in the EU-Türkiye Customs Union is a key driver of the CE transition in Türkiye. The EU is by far Türkiye's main trade partner, with trade relations based on an Association Agreement from 1963 and a Customs Union Agreement, which entered into force in 1995. In 2023 over 41 percent of Türkiye's exports went to the EU, led by machinery and transport equipment (automotive), clothing, chemical products, agriculture and raw materials. As the EU's CE policies evolve and become more stringent, for example with the introduction of product-level standards such as recycled material use requirements and product environmental footprints, Türkiye will need to ensure regulatory alignment to maintain preferential access to the EU internal market.

A successful CE transition in Türkiye will also help the EU achieve its CE goals of enhancing material efficiency and reducing environmental impact. A significant portion of the EU's material consumption and footprint is based on imports, with 11 percent of domestic material consumption and nearly 36 percent of the total footprint being imported.[10] A CE transition in Türkiye will therefore also benefit the EU's CE transition, as it will be difficult for the EU to achieve CE objectives alone, especially in textile and automotive sectors for which it has highly intertwined value chains. Türkiye is a central partner in these industries and therefore has a significant influence on promoting sustainable practices and technologies also in the EU. Given the tight trade relationship between the EU and Türkiye, the EU's transition to a CE is best achieved through cooperative and collaborative strategies with Türkiye's government and firms, including those on the periphery of the supply chain.

This report[11] highlights the importance of a deliberate, strategic, and articulated approach toward transitioning the Turkish economy to a CE, blending immediate actionable steps with a forward-looking long-term strategy. By moving forward with flexibility and vision, Türkiye can use its distinct advantages to not only respond to the changing global economy but also to lead in sustainable innovation and resilience, establishing a model for others in the worldwide move toward a more circular and thriving future.

[9] EU (European Union). 2020. "Regulation (EU) 2020/852 of the European Parliament and of the Council of 18 June 2020 on the establishment of a framework to facilitate sustainable investment, and amending Regulation (EU) 2019/2088." https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex%3A32020R0852.

[10] World Bank. 2022. *Squaring the Circle - Policies from Europe's Circular Economy Transition*.

[11] This paper presents the summary of World Bank policy analytics focused on the economic, trade, and industry aspects of the CE transition in Türkiye. The analysis summarized in this report, focuses on three components: (a) macroeconomic impacts of CE policies, (b) exposure to evolving CE policies in major trade partners, and (c) prioritization of the industrial sectors that can accelerate the CE transition.

1. Macroeconomic Impacts of the CE Transition in Türkiye

To understand the opportunities and challenges of the CE transition in Türkiye, this chapter explores a set of policy scenarios, using an economy-wide modeling framework. The chapter investigates the implications of CE-specific policy measures on various dimensions of Türkiye's economic, social, and environmental well-being, such as resource productivity, competitiveness, environmental sustainability, inclusion, economic security, and developmental impacts. The analysis uses a baseline scenario in which Türkiye and other countries implement their NDCs[12] and a stylized representation of the policy package necessary to support Türkiye's CE transition, thus allowing quantification of their potential economic impacts and trade-offs.

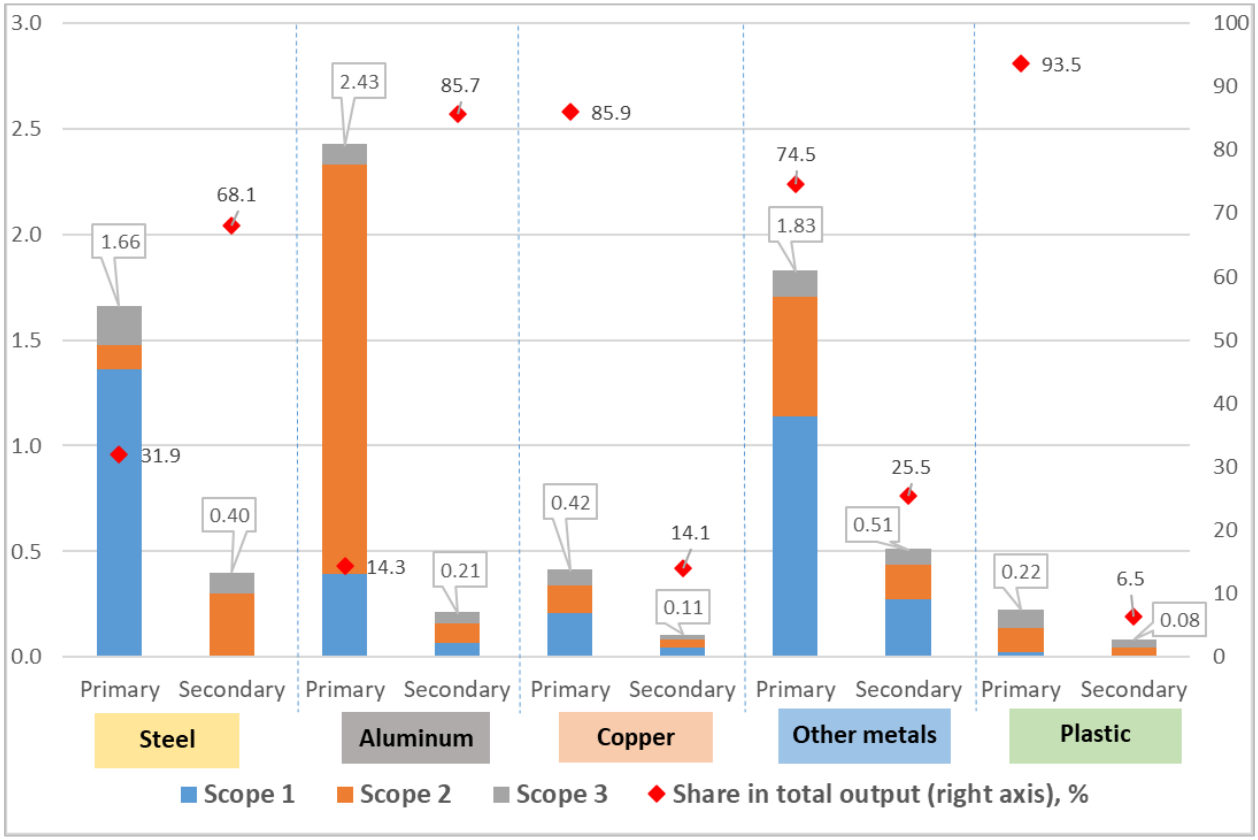
An innovative analytical framework tailored to Türkiye

This analysis deploys an innovative computable general equilibrium (CGE) modeling framework to assess—for the first time—the macroeconomic impacts of the CE transition in Türkiye. The economy-wide CGE framework[13] uses a specific version of the Global Trade Analysis Project (GTAP) Circular Economy Database (GTAP-CE), which introduces additional disaggregation of certain sectors and incorporates material flow accounting for the selected commodities.[14] In addition to allowing for a detailed representation of the alternative production technologies[15] and underlying virgin materials, this framework enables an understanding of the effects of specific CE policies and measures, including by modelling the GHG emission effects of alternative production technologies and materials.

A central goal of the analysis is to understand the interaction between CE policies and objectives and Türkiye's climate-change-related policies and objectives. Figure 1 provides an overview of carbon intensity by emission scopes[16] and the share of output across production technologies[17] for selected sectors in Türkiye as represented in the GTAP-CE Database. Three important observations arise from this representation. *First,* there is a substantial gap in emission intensities between primary and secondary production technologies as primary production technologies require more substantial energy inputs. Such a gap in emission intensities requires a mitigation potential for transitioning from primary to secondary production technologies. *Second,* there is a substantial variation in primary versus secondary output shares across sectors in Türkiye. While sectors like steel and aluminum have relatively high secondary production shares (in a range of 70–80 percent), other sectors, including other non-ferrous metals and plastic show substantially lower shares of secondary production (in a range of 7–25 percent), thus indicating different opportunities in improving circularity practices across various activities. *Finally,* there is a difference in the composition of emissions by scope across primary and secondary production technologies. In a number of commodity cases, such as steel, copper, aluminum, and other metals, primary production technologies have a higher share of scope 1 emissions because they rely on fossil fuel inputs. Secondary production is more electricity intensive and thus has a higher share of scope 2 emissions. This also means that decarbonization of electricity generation would reduce the emission intensity of secondary production more (in relative terms) than of primary production.

[12] Based on the first round of NDC submissions.
[13] The analysis relies on the recursive dynamic global CGE model ENVISAGE, calibrated to the GTAP-CE database (van der Mensbrugghe 2019). The model captures the transactions between all key agents in the economy. Firms purchase input factors (for example energy, materials, labor and capital) to produce goods and services. Households receive the factor income and in turn demand the goods and services produced by firms. Equality of supply and demand determines equilibrium prices for factors, goods and services. (van der Mensbrugghe, D. 2019. "The Environmental Impact and Sustainability Applied General Equilibrium (ENVISAGE) Model. Version 10.01." Center for Global Trade Analysis, Purdue University. https://mygeohub.org/groups/gtap/envisage-docs.)
[14] The GTAP-CE database introduces sectors splits, which provide a more detailed representation of categories like metallic and non-metallic minerals mining, rubber and plastic products, iron and steel, as well as non-ferrous metals. Corresponding sectoral splits are developed for all 141 regions reported in the GTAP database, including Türkiye as an individual country. Implemented disaggregation utilizes data on cost structures and output values of the sectors under split, as well as captures the bilateral trade patterns of the commodities in focus. Introduced distinction in production technologies for such sectors as plastic, iron and steel, aluminum, copper, and other non-ferrous metals allows to separate primary (relying on virgin materials, for example, iron ore) and secondary (for example, production using recycled scrap) production processes.
[15] These might include a representation of the primary and secondary production processes, recycling activities versus activities using virgin inputs (for example, metal ores, fossil fuels, non-metallic minerals, and so on).
[16] Carbon intensity refers to emissions per USD 1 of final use (consumption or export) of the corresponding product.
[17] Output refers to domestic (Türkiye's) output/production of the corresponding commodity.

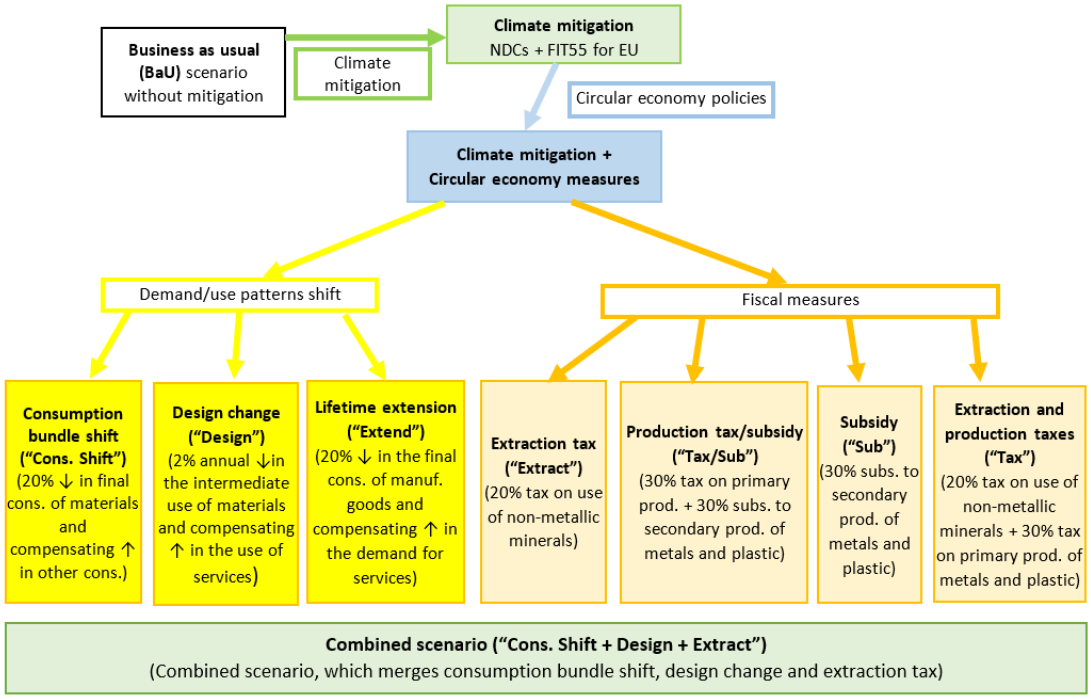
Figure 1. Carbon intensity by emission scopes (kg CO_2 per US$) and shares in total output for selected sectors in Türkiye



Source: Original elaboration.
Notes: Scope 1 emissions correspond to direct emissions from the combustion of fossil fuels. Scope 2 emissions are associated with emissions from the generation of electricity used in the corresponding production process. Scope 3 emissions are all the remaining emissions throughout the value chains embodied in the corresponding commodity (for example, emissions from the production of tires used in the car manufacturing).

The analysis consists in testing the effects of a set of CE-specific measures imposed on top of a baseline and a climate mitigation scenario. The baseline scenario covers 2014–2030 with given growth rate assumptions for GDP and population and static fiscal policies. The mitigation scenario incorporates Türkiye's NDC from 2021, which assumes a 21 percent reduction in GHG emissions in 2030 compared to the baseline. The CE-specific measures cover both demand/use-side interventions, as well as fiscal measures (see Figure 2). Demand-side measures include a consumption bundle shift (reduction in demand for material-intensive sectors with a compensating increase in demand for other goods and services), change in material design (reduction in the intermediate use of materials with a compensating increase in demand for services such as engineering and design), and lifetime extension (reduction in the final consumption of manufactured goods and increasing demand for services to maintain a longer lifetime for these commodities). Fiscal measures include an extraction tax on non-metallic minerals mining, production tax on primary activities and subsidy to secondary activities for metals and plastic, subsidy to the secondary production of metals and plastic, and a combination of extraction taxes and taxes on primary production activities. In addition, to explore the potential synergies and tradeoffs across various policies and measures, the combined scenario is developed, which merges a consumption bundle shift, design change, and an extraction tax.

Figure 2. Scenario framework



Source: Original elaboration.

Türkiye's material demand is expected to increase despite improvements in material intensity

Non-metallic minerals currently dominate supply and demand and are central to Türkiye's material intensity. In volume terms, both from the production- and consumption-based perspectives,[18] non-metallic minerals (gravel, sand, limestone, and so on) dominate the mix, accounting for around 92 percent and 85 percent of the composition, respectively. This share is lower from the consumption-based perspective, reflecting that Türkiye is an importer of fossil fuels. In general, non-metallic minerals and their products (for example, concrete) have lower recycling opportunities compared to some other raw inputs, such as metal ores, partly reflecting their relatively low economic value and thus the economic benefit from recycling (for example, it is much more economically attractive to recycle copper or gold than concrete or asphalt). In this regard, if one focuses on the reduction in economy-wide material intensity considering all material inputs, non-metallic minerals is the commodity group that could allow achieving major progress in this regard.

Türkiye's economy is projected to see an absolute increase in the use of all material inputs, tempered by a moderate reduction in material intensity for all virgin inputs except metal ores. The increase in material use is driven by GDP growth and—to a lesser extent—population growth. Between 2022 and 2030, production-based material use increases anywhere between 3 percent in the case of coal and up to almost 40 percent in the case of metal ores. Similar trends are observed in the case of consumption-based accounting. When these trends are translated to material intensities per unit of GDP, that is, use of materials per US$1000 of GDP (in constant prices), results suggest that the material intensity declines for all commodities except metal ores. The most substantial improvements in material intensity are observed for coal—16–20 percent in 2030 compared with 2022, depending on the accounting approach.

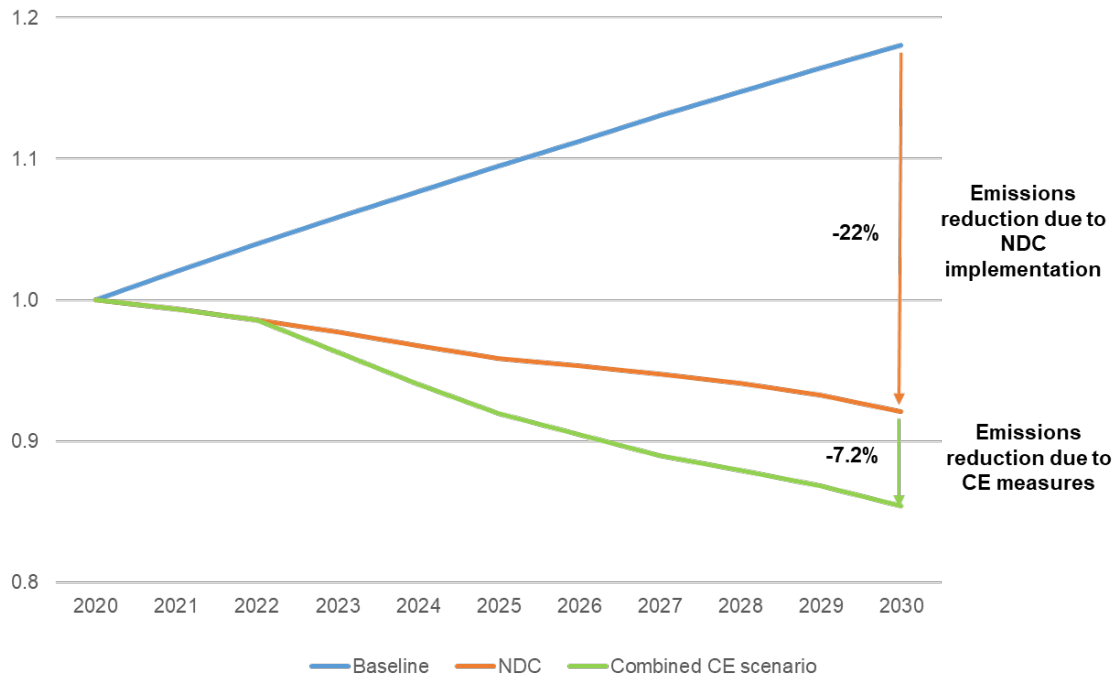
[18] This analysis distinguishes between production-side and consumption-side accounting. *Production-based* accounting adds domestic extraction and imports of the corresponding raw commodity and subtracts exports (all in volume terms). From a *consumption perspective*, raw materials used in the production of exported goods should be considered in the importing country.

CE policies can support the achievement of Türkiye's climate mitigation objectives

Climate policies alone will not be sufficient to induce circularity and reduce material consumption. The implementation of Türkiye's NDC will reduce fossil fuels use and CO_2 emissions, however, with limited impacts on the use of other materials. In the baseline scenario economy-wide fossil fuel combustion CO_2 emissions increase by around 18 percent in 2030 relative to 2020 levels. In the climate mitigation scenario, emissions from fossil fuel combustion are 22 percent below the baseline or some 8 percent below 2020 levels. In particular, NDC implementation leads to a substantial reduction in the use of coal and—to a lesser extent—gas. The impact of mitigation policies on the use of other materials is less substantial.

However, increasing circularity can help reduce CO_2 emissions in Türkiye. Results suggest that the CE policies in Türkiye can contribute to additional reductions in the fossil fuels combustion CO_2 emissions—by over 7 percent in 2030 on top of the emission reductions in the NDC scenario (Figure 3). As a result, when NDC and combined CE scenarios are implemented simultaneously, CO_2 emissions from fossil fuels combustion decline by almost 28 percent with respect to no-mitigation baseline in 2030 or by 15 percent relative to 2020 levels. In this regard, one might consider CE policies as complementary to climate-specific policies, when achieving pr-defined mitigation targets, thus providing a broader range of potential climate policy options.

Figure 3. Economy-wide CO_2 emissions from NDC implementation and CE measures

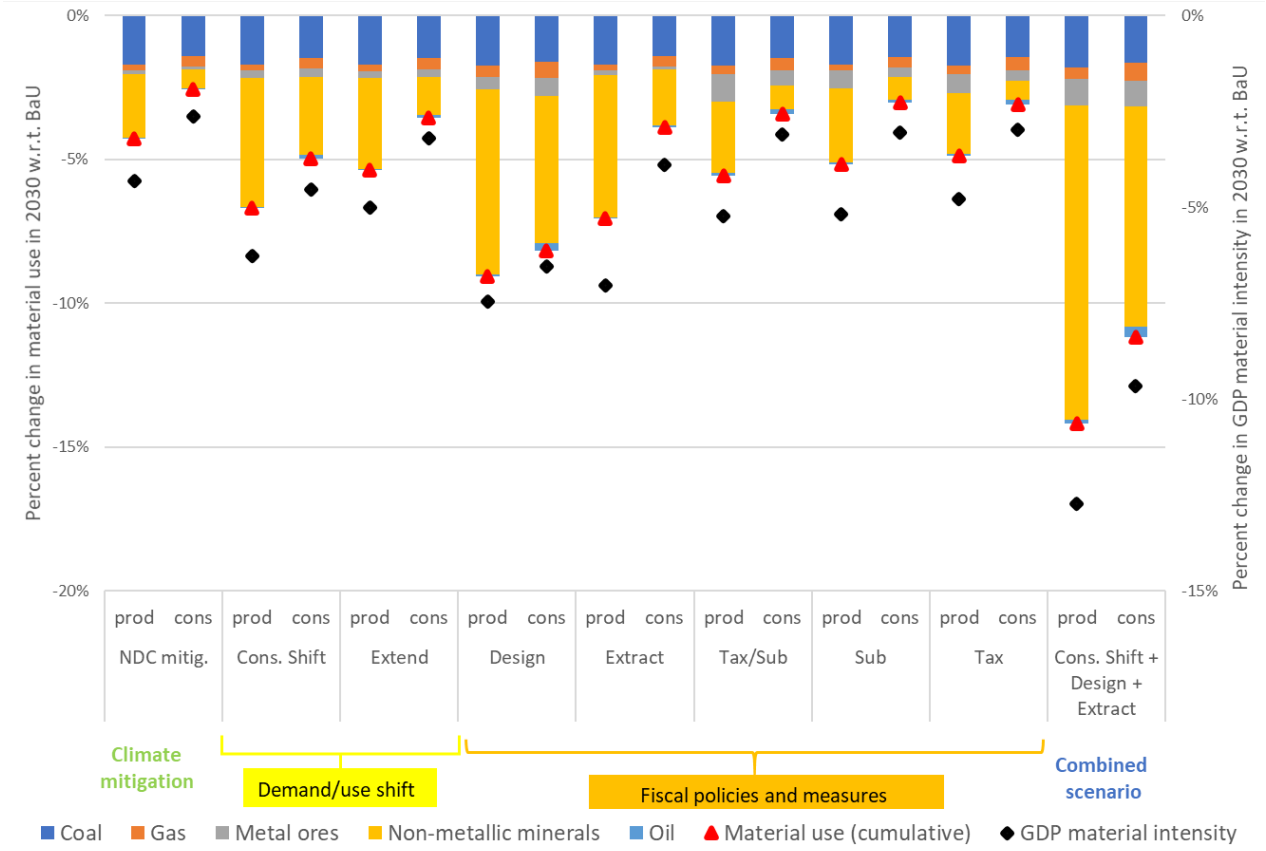


Source: Original analysis.

Rather than single measures, supporting the transition will require policy packages

CE policies allow to substantially reduce material demand over time but a combination of various policy measures is needed to effectively support the CE transition. A combination of CE policies can reduce production-based material use by over 14 percent in 2030 compared to the baseline (under the combined scenario, see Figure 4)—an additional 10 percentage points reduction on top of the climate mitigation scenario. Similar reductions are observed for GDP material intensity. Several important policy insights arise from the analysis.

Figure 4. Impact of different policies on material use (right axis) and GDP material intensity (left axis) (2030 with respect to baseline, percent)



Source: Original elaboration.
Notes: The 'prod' and 'cons' labels correspond to production- and consumption-based material accounting methods (quantities). Percent changes are reported relative to the total material use under baseline in 2030.

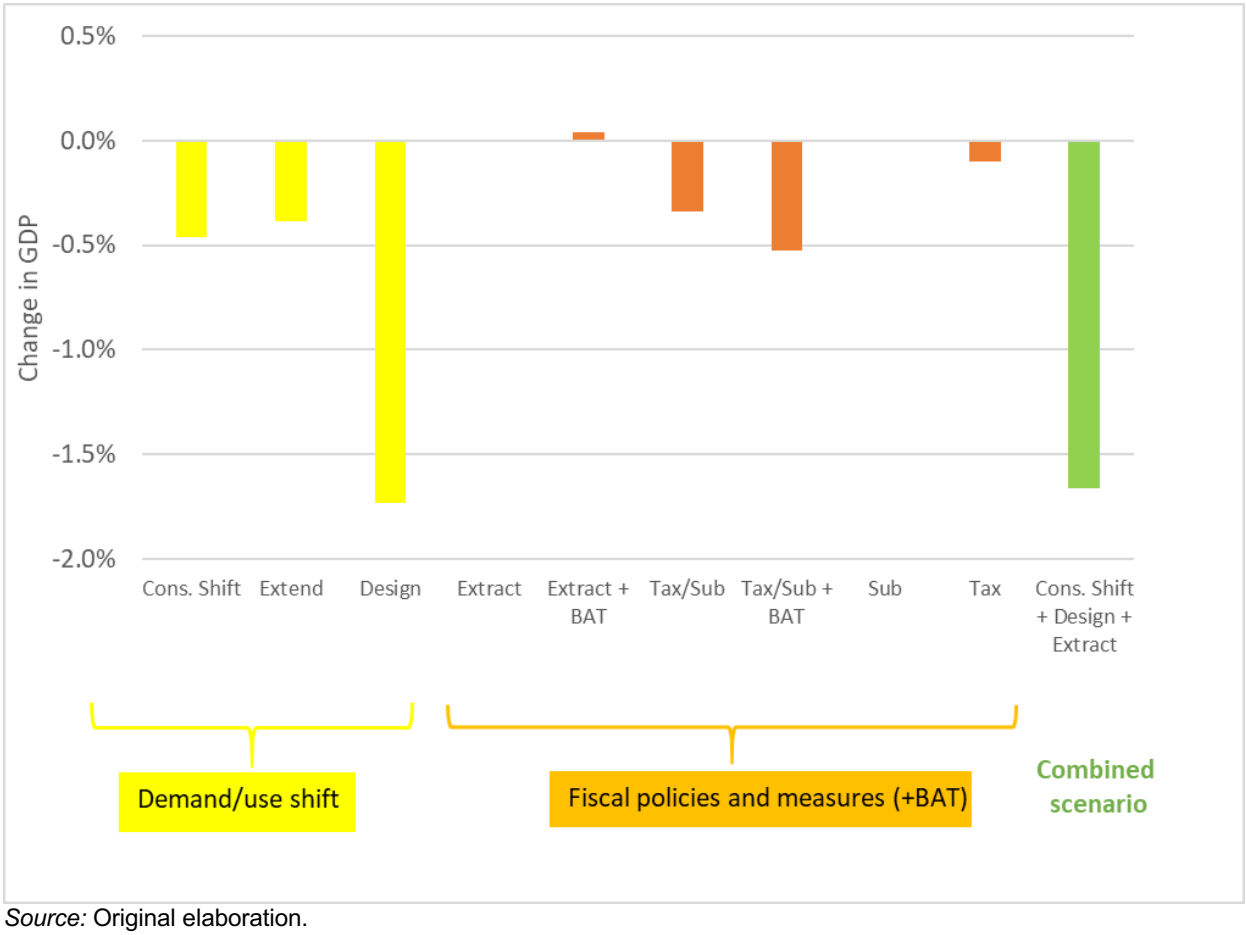
Combining demand-side and supply-side policies allows for the achievement of more ambitious CE targets. Demand-side measures, such as design change or product lifetime extension, allow reducing overall material demand but have limited impact on the structure of the production processes. In other words, consumers purchase fewer cars but car manufacturers still rely on the primary metals and plastic in the production process. Supply-side measures (for example, extraction tax, production subsidy), on the other hand, are more efficient in changing the composition of technologies, that is, incentivize car manufacturers to rely more on the recycled metals and plastic, thus substituting virgin material inputs. When these two sets of measures are combined, they complement each other—reducing overall material demand and shifting production patterns toward recycled inputs. Results also suggest that the extraction tax, while operating on a much more substantial base (the weight share of non-metallic minerals in the overall material production in Türkiye is around 90 percent, while the share of metal ores is only 2 percent), tends to lead to a more significant reduction in the overall material use compared to subsidies and/or taxes imposed on the primary/secondary production activities. Another observation is that demand-side measures are more efficient in reducing the use of non-metallic minerals, while supply-side measures lead to a more substantial reduction in the use of metal ores by promoting a shift toward recycling activities.

Achieving absolute decoupling is complicated by a substantial share of non-metallic minerals in Türkiye's material use patterns (85–90 percent of total material use). Non-metallic minerals are primarily used in the production of construction materials (gravel, cement, bricks, and so on), which are hard or not economically feasible to recycle. In addition, non-metallic minerals have a long lifecycle with an inflow of raw materials in a specific year substantially higher than the outflow. At the same time, CE policies have a more substantial impact on commodities with higher recycling possibilities, such as plastics and metals, increasing the share of secondary production in 2030 by up to 18 percentage points (in the case of steel) compared to the baseline case – assuming the necessary scrap collection and processing capabilities introduced by modeled policies.

The economic dividend of supporting the transition can be reaped by addressing Türkiye's existing skills gap

The reduction in the EU demand for materials induced by EU CE policies is likely to hurt Türkiye's exports.[19] In line with scenario assumptions, CE measures are implemented simultaneously by the EU and Türkiye. The resulting reduction in the demand for material-intensive goods in the EU results in declining imports of this type of commodities by the EU, including those from Türkiye. Since the EU is a major destination for Türkiye's exporters, this also has a substantial impact on the overall decline in the country's exports and a reduction in the manufactured goods share in the total exports. On the imports side, findings suggest that manufactured goods as well as metals and chemicals are those that experience the most substantial declines in terms of Türkiye's imports from the EU. These findings point to the need for Türkiye to implement ambitious CE policies to retain its future export competitiveness (see Chapter 3).

Figure 5. Change in real GDP across scenarios with respect to baseline, percent



Source: Original elaboration.

The costs of implementing CE policies are relatively moderate (in most cases, within 0.5–1.7 percent of real GDP in 2030 compared to the baseline) and do not include co-benefits of achieving CE objectives. In the combined scenario, real GDP decreases by about 1.6 percent (Figure 5). While this may seem substantial, it is important to note that this figure does not consider multiple co-benefits. For example, reductions in CO_2 are often accompanied with reductions of other air pollutants (for example, SO_2, NO_x, $PM_{2.5}$, and so on). This results in lower mortality rates and can reduce the overall costs of mitigation. Similarly, material extraction is putting major pressure on ecosystems. Reducing material extraction can improve the ecosystem services and provide valuable economic benefits. Finally, additional incentives to apply secondary production technologies and recycling activities could stimulate endogenous technological improvements, thus reducing CE transition costs and strengthening positive spillover effects.

[19] Trade-related results reported in this section correspond to monetary units (value terms).

While overall macroeconomic costs are expected to be moderate, an increasing skill wage gap might be a concern. A skill wage gap is defined as the ratio between the wages of skilled and unskilled workers. The results suggest that in the case of demand-focused measures, low-skilled workers are affected more adversely than the high-skilled labor force. For instance, changing the design of the products requires additional research and development (R&D) and engineering service inputs but fewer inputs of lower-valued goods, such as raw materials, thus benefiting high-skilled workers. In this regard, targeted policy measures might be needed to mitigate the regressive distributional outcomes of the CE transition and support labor force reskilling.

2. Positioning Turkish Industry in Circular Global Value Chains

In the context of the EU-Türkiye Customs Union, the CE transition is not only a matter of environmental stewardship but also of strategic alignment with the EU's tightening environmental policies in the context of the Green Deal. As the EU advances toward more sustainable practices, Türkiye, with its deep economic and trade ties to the region, finds itself at a crucial juncture. Embracing CE principles can position Türkiye as a key player in this evolving green landscape, enabling greater economic growth alongside sustainability. The general motivation for Türkiye's transition to a CE is therefore twofold: it addresses the evolving regulatory environment of its principal trade partner, the EU, and it aligns with Türkiye's own environmental and sustainability objectives, exemplified by its ambitious Zero Waste Initiative.

The EU's progression toward stricter environmental standards presents Türkiye with both challenges and opportunities. Adapting offers a chance not just for compliance but for innovation and a more significant role in sustainable global markets. Like all emerging countries, Türkiye faces the choice between continuing to pursue the linear development strategy initiated in past decades or seizing new growth opportunities through the CE transformation. The former, characterized by high resource consumption and waste, poses significant challenges in terms of energy and resource efficiency. Transitioning to a CE offers a pathway to address these challenges. It promises enhanced job resilience and a transformative economic impact by fostering growth in green sectors. This shift allows Türkiye to leverage its strengths while mitigating environmental issues.

The EU's regulatory evolution toward sustainability and circularity, given Türkiye's economic integration with the EU, acts as a powerful catalyst for Türkiye's transformation. Noncompliance with these regulations poses significant risks, including reduced market access and competitiveness, while adaptation could boost Türkiye's economic robustness and secure its EU market position. Proactively engaging with these regulatory changes is crucial for Türkiye's economic prosperity and continued development progress.

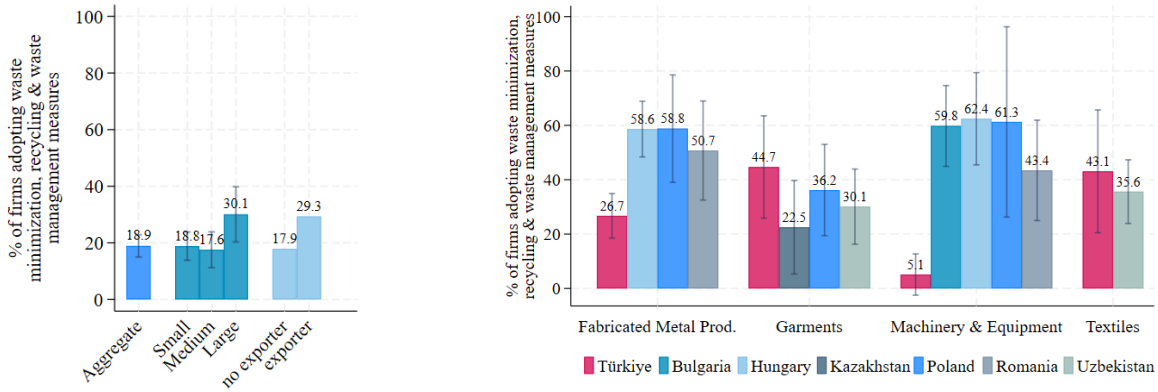
This chapter examines the transition of Turkish firms to align with CE principles, highlighting both immediate needs and the longer-term opportunities from engaging in a transition agenda. The chapter stresses that the changing landscape toward CE in the EU offers a significant strategic opportunity for Türkiye to strengthen its position in global markets and build resilience against economic shocks.

Adoption of CE practices in Turkish industry

Nearly one-fifth of Turkish firms have already adopted resource-efficient production technologies, including waste minimization, recycling, or waste management practices.[20] Notably, firms in the garments and textiles sectors have been much more successful in introducing waste and recycling management than their counterparts in fabricated metal products and machinery sectors (Figure 6). While more than 40 percent of firms in the Turkish garments and textiles sectors adopted circularity practices, a proportion substantially higher than the one posted by Europe and Central Asian peers, Turkish firms need to increase the circularity practices in the fabricated metal products and the machinery and equipment sectors, especially in comparison to their peers in Hungary, Poland, and Romania. In line with international evidence, in Türkiye, there was a higher number of larger firms as well as firms selling on the international markets (that is, direct exporters) adopting resource-efficient solutions.

[20] World Bank Enterprise Survey (WBES 2019).

Figure 6. Adoption of CE practices



Source: Original analysis.
Note: These figures shows the percentage of firms that adopted CE practices such as waste minimization, recycling, or waste management in the three years preceding the latest WBES. The left panel depicts adoption rates in the aggregate Turkish economy, broken down by establishment size and export status. The right panel illustrates adoption rates in the four CE priority sectors with representative coverage and adds sectoral averages of surveyed Europe and Central Asian economies with the same industry stratum. Whenever inference is possible, 95 percent confidence intervals are included.

Nearly 35 percent of surveyed firms have taken action on energy efficiency improvements, with such initiatives being more common in larger companies. Companies in the textiles sector show significant energy efficiency activities, outpacing some regional competitors. In contrast, Turkish firms need to increase energy efficiency in the machinery and equipment sector, especially in comparison to their peers in Bulgaria, Hungary, and Poland. Among non-adopters, there is a noted lack of financial resources and prioritization for these initiatives, especially among smaller and domestic-oriented firms.

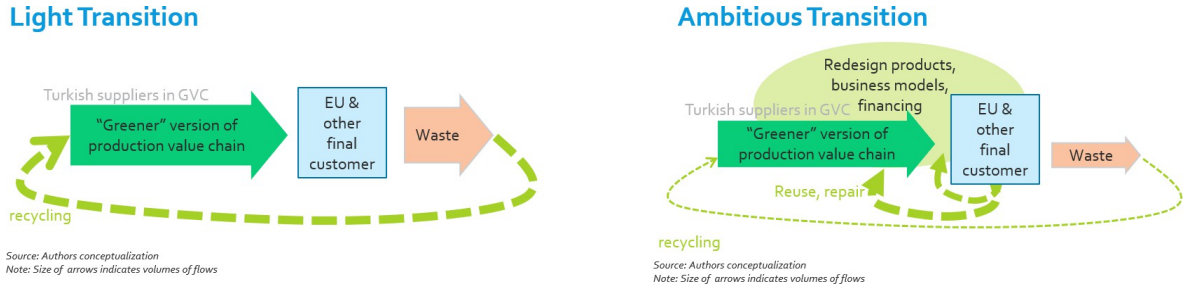
Turkish industry has significant scope for improving its resource productivity and carbon footprint. Türkiye's overall resource productivity ranges in the bottom half in Europe, with approximately 1.8 units of purchasing power adjusted GDP generated out of every kilogram of domestic material consumption.[21] This compares to an EU average of 2.3 purchasing power standards per kilogram.

Two possible CE futures for Türkiye

The shift to a CE can be achieved through varying approaches, each with distinct implications for Turkish firms. We categorize such different approaches as light and ambitious 'CE transition futures' (Figure 7). The light transition aims at a more efficient use of materials and an increase in reuse and recycling through measures that are already in progress or can be implemented in the immediate future. The ambitious transition envisions enhanced environmental standards and a comprehensive redesign of products, business models, and financing. The light approach is a conservative strategy, while the ambitious transition in many respects represents a higher-risk, higher-returns strategy that can help Turkish firms to shift toward producing and exporting higher value-added goods and services. The approach is ambitious in that it involves transitioning from a primarily one-way flow of goods to a dynamic two-way exchange. However, although the shift introduces uncertainty, it offers opportunities for significant advancement without necessarily incurring high costs.

[21] Domestic material consumption is computed as domestic material inputs, that is, the sum of domestic extraction plus physical imports minus physical exports.

Figure 7. Two CE transition scenarios for Türkiye



Source: Original elaboration.

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Factors enabling CE readiness

In the global move toward circular economies, strategic positioning and competitiveness hinge on several key factors, each playing a pivotal role in enabling a successful transition. At the core of the CE is the need for effective traceability and robust digital monitoring systems. These systems are crucial for ensuring carbon and material efficiency in key sectors, tracking resource flows, identifying inefficiencies, and minimizing waste. Access to and use of recycled inputs is another fundamental aspect of a successful transition. The demand for recycled inputs under a weak CE scenario tends to increase, presenting countries in transition with two strategic options: securing foreign recycled materials or developing a domestic recycling industry. Hence, fostering growth in domestic recycling rates and securing adequate access to imported recycled materials are important and complementary enablers. As economies progress from 'light' to full circularity, the focus expands from merely ensuring access to recycled inputs to maintaining products in the usage cycle for longer periods, thereby reducing reliance on both new materials and recycled ones.

Ultimately, the transition requires innovation. Technological upgrades, advancing the innovation frontier, and upskilling the workforce are therefore fundamental ingredients as well. Seamlessly transitioning to the CE necessitates significant technological advancements across all sectors of the economy. As circular technologies and practices become more prevalent in the domestic economy, the cost of adoption per unit of output decreases more rapidly. Technological upgrades include at least three key strategies, that is, swiftly deploying technologies that conserve resources, upgrading machinery, and investing heavily in workforce upskilling to reduce the material footprint of production. Agility in adopting and adapting to the new technologies is therefore crucial for implementing CE practices, whether in 'light' scenarios or more comprehensive ones.

However, transitioning effectively goes beyond mere technological upgrades; it requires a strong push toward innovation and R&D. It is about rethinking business models, products, and processes to fully integrate circular principles. Innovation in the value chain is key, demanding a proactive stance in crafting new, sustainable business strategies. The goal is to create new products from prototypes or new patents and to make commercially viable technical solutions which may be still at the experimentation stage. Those firms and countries who lead in such frontier efforts can secure a first-mover advantage once the innovation becomes economically viable.

Clearly supporting such transformations requires new skills and competencies across the entire society. It also requires carefully designed, adaptable financing frameworks. These frameworks must cater to the diverse needs of various firms and industries, facilitating their shift toward more asset-light, circular business models. Such financial support structures should be inclusive, accommodating the evolving challenges of different market players during this structural transition. A comprehensive financing strategy that leverages the different sources of financing is suggested. Financing can originate from many different sources: own capital; intra-GVC (global value chain) financing; private financial investors, such as institutional investors and private equity; and public subsidies and finances. These differ from one another in time horizon, investment size class, criteria for financing, and domestic versus international considerations.

Finally, demand and supply dynamics also matter. The broader context of consumer preferences and market demands significantly steers the transition's pace and direction. Aligning national sustainability trends with global movements and responding to the changing demands within key partner

markets can accelerate the adoption of CE practices. Domestically, fostering a shift in material consumption patterns can act as a powerful catalyst, bolstering the local private sector's capacity for circular initiatives.

The way forward under a 'light' CE transition

A one-size-fits-all reform is not going to be helpful. The relationship between costs and transformation efforts is not straightforward, primarily due to the diverse nature of industries and sectors within the Turkish economy. This diversity means that while some sectors and firms can rapidly transition, supported by necessary reforms, others may only undergo incremental changes due to external decision-making factors. This necessitates a focus on adaptive transformation in such sectors and firms. Meanwhile, other sectors and firms should have higher aspirations, since they can catalyze transformation, achieve leadership roles in the relevant CE GVCs, and enhance competitiveness through innovation-led growth.

In the very short term, and with the 'light' approach in mind, three improvements are paramount.

- ***First,* accelerating the adoption of mature technology and critical tools is essential for resource-efficient production.** For example, there is an urgent need for firms to access recycled inputs and monitor production through digital tracing infrastructure.
- ***Second,* the problem of insufficient scale and high fixed costs to invest in the transition, particularly for smaller firms and lower-tier suppliers in GVCs, needs to be addressed.** This includes targeted financing options to address the initial investment hurdles faced by businesses; shared infrastructure, such as wastewater treatment facilities and environmental monitoring systems, to support sustainable practices; and other shared resources such as green transformation centers and one-stop shops for information and implementation of new regulation.
- ***Third,* institutional and coordination enhancements are needed to help address the coordination shortfalls and promote innovation, observed in the preparation of this analysis.** There are two dimensions to this, one about the relations with the EU and one concerning domestic platforms for intergovernmental and public-private coordination and partnership. Specifically, Türkiye should strengthen ties with EU entities and ensure regulatory alignment while also advocating for regulations that consider the unique needs of Turkish companies. In particular, the Government of Türkiye should operate a balancing act between maintaining an open dialogue with the EU counterparts to meet evolving regulatory requirements and carefully timing the transition to EU standards, to optimize the trade-off between costs and market opportunities. In addition, it should foster collaboration among public stakeholders in Türkiye (Ministries of Trade, Environment, Urbanization and Climate Change, Industry and Technology) and with private sector entities, to unify the national approach toward sustainability and CE transitions.

The way forward under an 'ambitious' CE transition

In the envisioned 'ambitious' scenario, this analysis aims to position Turkish firms at the forefront of new and emerging industries, creating a fertile ground for sustained growth, innovation, and the advancement of the CE. The focus is on bolstering R&D activities, pioneering innovative business models and processes, and nurturing green skills. Our findings reveal a direct link between a firm's scale, its reliance on import and export activities, and its R&D investment. Yet, in comparison to their peers in Europe and Central Asia, Turkish companies tend to lag in R&D spending. The shift toward a CE emerges as a possible avenue for bridging this gap. The Turkish private sector exhibits remarkable resilience and adaptability, and it is poised to capitalize on its integration into European initiatives, connections with global GVCs, and exposure to the most innovative practices. This positions Türkiye favorably to embrace fully the CE, provided there is sufficient and long-lasting governmental backing.

The field research undertaken for this analysis highlights the dynamic strides local entrepreneurs are making in adopting existing sustainable innovation solutions. Examples include polyester recycling and the implementation of waterless dyeing techniques for synthetic fibers.

These efforts have been further propelled by Türkiye's involvement in EU initiatives, such as Horizon Europe projects focusing on textile and plastic recycling. These successes illustrate the potential of Turkish businesses to lead in eco-friendly business practices and technological breakthroughs, even in ambitious transitions to a CE. For instance, global innovation in areas like cotton recycling and waterless dyeing of non-synthetic textiles could benefit from Turkish ingenuity, contingent upon a supportive long-term policy strategy.

Beyond the immediate priorities outlined above, a successful and robust transition into global CE industries requires three longer-term actions. *First,* Türkiye's government should invest in green skills and in raising awareness about the CE among firms, workforce, educational institutions, and the general public. *Second,* it should foster an innovative ecosystem that supports R&D, new business models, and environmental sustainability through tailored finance, subsidies, incentives, and cross-border collaborations. *Finally,* to catalyze sufficient private investment there is the need for the government to signal to the private sector long-term commitment and policy coherence in promoting this agenda. The government has already demonstrated its commitment to the green agenda by the Green Deal Action Plan and upcoming National Circular Economy Action Plan. Nonetheless, the government should also communicate its commitment to support broader global initiatives promoting green markets and sustainable investment vehicles. This can be achieved through fostering a national vision for sustainable and inclusive development and a mindset shift: rather than an imperative, the CE transformation should be viewed as an opportunity to upgrade Turkish firms' position into GVCs, enhance export competitiveness, and build resilience against economic shocks through the adoption of sustainable practices**.**

The analysis highlights the importance of a deliberate, strategic, and articulated approach toward transitioning Turkish firms to a CE, blending immediate actionable steps with a forward-looking long-term strategy. By moving forward with flexibility and vision, Türkiye can use its distinct advantages to not only respond to the changing global economy but also to lead in sustainable innovation and resilience, establishing a model for others in the worldwide move toward a more circular and thriving future.

3. Prioritizing Industries for Building a Competitive Circular Economy in Türkiye

In a CE, strong connections between industries are essential. These connections ensure the efficient flow of materials, information, and resources, facilitating innovation, reducing waste, and optimizing resource use throughout the value chain. When these connections are weak or missing, the flow of resources and information is disrupted, hindering the distribution and sale of circular products. This disruption reduces the overall value generated by supply chains, leading to inefficiencies in using economic resources and preventing capital from being fully productive in a sustainable economy. However, the potential benefits of a CE for Türkiye are immense, including reduced environmental impact, increased resource efficiency, and enhanced economic resilience.

For policy makers, fostering strong links between industries is not just crucial but also a powerful tool in transitioning to a sustainable CE. In a CE, industries and markets are interconnected in complex ways that facilitate the continuous cycling of resources. This creates a closed-loop system where waste is minimized, and resources are reused and recycled. However, a successful CE also requires openness to new market relationships and connectivity, driving innovation and creating new business opportunities and investments. Effective policies must focus on both strengthening existing connections and making new ones to develop strong, competitive CE markets that are sustainable and continuously evolving. By doing so, markets can support each other, creating a self-reinforcing system where economic activities feed back into the chain, enhancing sustainability and economic resilience. Policy makers, with their unique position, can play a pivotal role in this process.

For Türkiye, stronger links between industries provides unique opportunities for growth and development. Currently, the connections between high-potential circular industries (such as chemicals, manufacture of basic metals, plastics, and non-metal minerals) and key industries that rely on them (such as computers, electronics, food products, machinery and equipment, motor vehicles, and textiles) are weak. Additionally, the connections between these key industries and their supporting sectors (such as business services, transportation and storage, and wholesale and retail) are also weak. Weak connectivity means that industries struggle to efficiently share resources and information, leading to higher costs and reduced competitiveness. However, by addressing these challenges, Türkiye can not only strengthen its economy but also lead the way in sustainable practices. Strengthening these connections involves improving collaboration between industries, investing in infrastructure that supports efficient resource flow, and implementing policies that incentivize sustainable practices. This, in turn, would attract further CE investments and enable more productive use of capital in a sustainable economy.

The analysis identifies gaps in the links of industries in six value chains by deploying network analytics and a market distortion assessment. The network analysis presented in this chapter provides policy makers with a data-driven decision tool to prioritize the development of links between core and closely related CE sectors, identifying gaps by comparison with networks in countries with higher level of implementation of CE policies. The analysis is structured into three main components: (a) core sectors: value chains prioritized by the EU which include sustainable design, reuse, remanufacturing, recycling, and repair and maintenance, among others; (b) supporting sectors: those closely related to key product value chains; and (c) ancillary sectors: connected as second tier to the supporting sectors.

The analysis focuses on six priority value chains identified by TÜBİTAK[22] for technology improvements associated with Türkiye's green transition ambitions and adaptation to the European Green Deal: iron and steel, aluminum, cement, plastics, fertilizers, and chemicals. For these core sectors, the analysis identifies 80 industries (see Annex 1) and 75 supporting and ancillary industries (see Annex 2) connected through their value chains that shall potentially strengthen the business opportunities and market challenges affecting the CE transition.

[22] Türkiye's Scientific and Technological Research Council.

Key characteristics of circular networks

Spillover effects from a circular industry are more strongly transmitted to other industries that are nearby (collocated) across local markets. Many economic transactions occur within local economies, especially for non-tradable goods. Consequently, a shock to one industry can have a significant impact on other collocated industries compared to less connected ones. For example, a shock to the textile industry, such as a sudden decrease in demand, could negatively affect the agriculture industry in a specific local market by reducing the need for raw materials like cotton. This, in turn, could lead to lower production levels, job losses, and reduced economic activity within the local market.

The analysis of the domestic economy network identifies opportunities for fostering circularity within local markets. Local circular industries play a crucial role in transitioning to a CE as they engage in economic transactions involving both tradable and non-tradable circular products. To fully harness the potential of these industries and strengthen local markets, it is vital to enhance demand and supply for circular products by integrating them into GVCs. Strategies should account for the proximity of industries and the business environment. By examining upstream and downstream connections between firms and industries, a comprehensive strategy can be developed to promote circularity and maximize the economic benefits of circular practices, guiding policy makers and business leaders in making well-informed decisions.

Integrating circular products into GVCs provides opportunities. By embracing a CE model, industries can tap into significant economic opportunities in prioritized value chains. This activity highlights the importance of understanding the domestic economy network to facilitate integration into GVCs. To achieve this integration, industries must build solid partnerships and adopt a system view that encompasses all participants in a supply chain and connected supply chains. The successful integration of circular products into GVCs can promote economic diversity and resilience, contributing to the global transition toward a CE, addressing pressing environmental challenges, and fostering sustainable development.

Understanding industry interdependence and circular value chains is essential. Comprehending the connections and relationships between industries and firms in circular product value chains is crucial for evaluating the economic impact of implementing CE practices and promoting circularity among businesses. Strategic industries hold potential as central players in establishing circular value chains, serving as suppliers and consumers of circular products.

Collaboration and partnerships between firms and industries are vital for driving the transition to a CE. This cooperation can involve sharing resources, knowledge, and best practices and jointly developing new circular products. Such collaborations can create new business opportunities, reduce costs, and enhance local economic resilience. By leveraging the strengths of different industries, the local economy can benefit from positive spillover effects, where the success of one industry can have a positive impact on the performance of others, ultimately leading to a more sustainable, resilient, and economically viable future.

Policies for a competitive CE transition in targeted sectors

Boosting competition in key industries is essential. To speed up Türkiye's transition to a CE, increasing competition within industries connected to targeted value chains is important. By focusing on successful industries (with high regional concentration) and making them even stronger, Türkiye can continue making progress in potential circular industries related to TÜBİTAK's priorities. Meanwhile, supporting and encouraging lower-performing industries (with lower regional concentration) to improve their business environment will allow them to contribute more effectively to the growth of the prioritized value chains.

Strengthening the primary and manufacturing industries related to TÜBİTAK's prioritized value chains and fostering collaboration and development within the tertiary sector is essential for the CE transition. This can be achieved more efficiently using finite resources like forests, soil, water, air, metals, and minerals. For example, in the textile industry, the government can incentivize using sustainable materials, such as organic cotton or biodegradable fibers, and promote recycling and upcycling of textile waste to reduce reliance on fossil fuels for synthetic fiber production. Furthermore, the government plays a significant role in promoting the efficient use of finite resources by creating policy frameworks, regulations, and incentives that drive businesses and consumers toward adopting circular

practices. For instance, governments can implement taxes or levies on the extraction of raw materials and provide tax breaks or subsidies for businesses that adopt circular practices, such as recycling or using renewable energy sources. Establishing partnerships and adopting a systems approach that includes all supply chain participants is vital for transitioning to a CE. Environmental industries, including renewable energy production, recycling, repair, maintenance, renting, and leasing, play a crucial role in this transition. They involve a wide range of products, services, technologies, and processes that serve various economic sectors.

The tertiary sector is particularly relevant for nurturing domestic supply chains and ensuring the smooth functioning of local economies. Service activities like consulting, design, engineering, computer services, and repair and maintenance for delivering and maintaining environmental goods, machinery, and equipment are considered of particular importance. Trade restrictions on services can have a negative impact on environmental service provisions due to their anti-competitive nature, which hinders the entry of new competitors. Efforts to eliminate barriers to trade in environmentally related services could substantially affect sector-wide productivity, skills, and earnings. Service liberalization, on the other hand, can be a source of economic performance gains, enhancing manufacturing productivity and coordination within and between firms. However, countries may miss opportunities for links within the services sector, remaining confined to providing natural resources for domestic and international production networks.

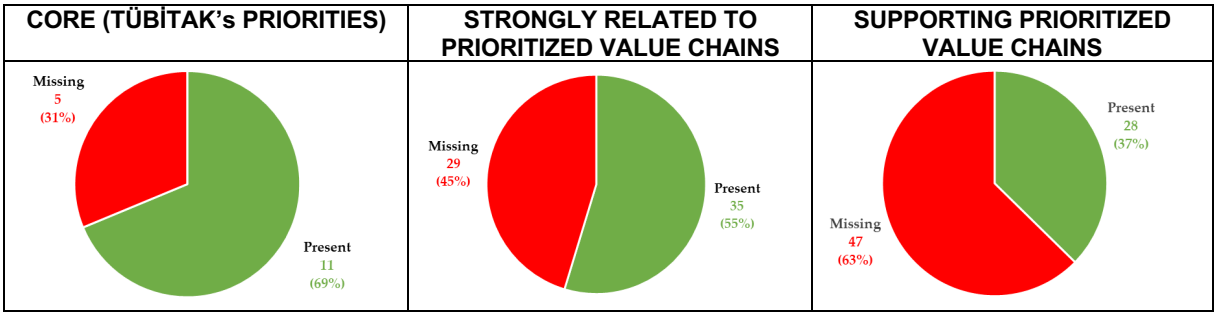
Firms operating in supporting industries in sectors such as other business sector services, transportation and storage, human health and social work, construction, and others need to enhance their competitiveness to facilitate and expedite the transition to a CE. By enhancing their competitiveness and adopting innovative solutions, these firms can contribute to a more sustainable future, reduce environmental impact, and ultimately drive growth in a CE. To foster the transition to a CE, firms in the transportation and storage sector can focus on optimizing their logistics networks and integrating eco-friendly transport solutions. This may involve utilizing electric vehicles, improving route planning to reduce fuel consumption, or investing in efficient warehousing and inventory management systems. In the construction sector, companies can promote green building practices, use sustainable materials, and implement waste-reducing methods during the construction process. These efforts can significantly decrease the environmental footprint of these industries and support the broader transition to a CE. In human health and social work, industries can also contribute to the CE by implementing innovative patient care and resource management approaches. This might include adopting telemedicine technologies to reduce transportation-related emissions, utilizing digital platforms for data sharing and collaboration, and incorporating sustainable practices to provide health services. By enhancing their competitiveness in these sectors, firms can not only improve the overall efficiency of their operations but also encourage sustainable development and contribute to the realization of a CE.

Next steps

The efforts toward circularity in Türkiye should be geared toward three main objectives aligned with the prioritized value chains.

***First,* it is vital to enhance the competitiveness of core industries related to TÜBİTAK's priorities, especially those lagging their European OECD counterparts.** Strengthening these industries will help build a solid foundation for the CE in Türkiye. According to Figure 8, 31 percent of industries fall into this category.

Figure 8. Core, strongly related, and supporting industries with the most extensive connections to other industries



Source: Original analysis.

***Second,* fostering the growth of upstream industries linked to the targeted value chains is essential.** These industries provide crucial inputs for the CE, and their development will help ensure a consistent supply of resources. Equally important is the support to downstream industries, which allows for the benefits of the CE to be spread across sectors, spurring growth and creating more opportunities for firms. Figure 8 indicates that 45 percent of industries are either upstream or downstream in the value chains.

***Third,* there is a need to promote investments in key industries that support circularity.** These industries play a pivotal role in ensuring the efficient functioning of the CE, and their development will help accelerate the transition to a CE in Türkiye; 63 percent of industries fall under this category.

In Türkiye, the regulations to foster circularity are focused on waste management and recycling. This chapter shows that there are gaps in the value chains that can be addressed with policies to incentivize more upstream interventions. Building upon the eco-design directive of the EU under discussion, Türkiye could adopt measures to support industries developing products that can facilitate the recovery of critical materials for the Turkish industry and/or to reduce the impact on landfills and waste generated by the domestic market.

For the targeted sectors in Türkiye, the aim of the policy makers should be to foster the creation of domestic markets, by generating demand-supply dynamics through regulations and incentives:

1. **Steel/aluminum.** Scrap metal can be contaminated by alloys or other materials. Introducing regulation to design products with limited use of alloys, conceived to facilitate disassembling or separation of the metal parts. A circular regulation could establish the maximum content of alloys, their specification to ease the separation of the main elements in the recovery process.
2. **Cement.** There are very few examples of pre-fabrication or modular design to facilitate the recovery of the materials at the end of life of a building. Demolition should be replaced by disassembling. Potential circular regulation should incentivize modular design, with the introduction of a building material registry as repository of recoverable materials from buildings. The minimum content of recovered material from the disassembling of old buildings for the new ones could offer the opportunity to establish a circular loop for this industry.
3. **Plastics.** Plastic recovery shows low rating in Türkiye due to contamination of plastic waste. Improving circularity requires introducing regulation to establish minimum content of recycled plastics, reducing content of additives, and reducing multilayer products in the design of the products.
4. **Chemicals.** Additives could limit the recovery of materials at the end of life of products. Introducing regulations to shift the fabrication of products by limiting the use of additives that could affect the reuse/recovery of products and materials should contribute facilitating circularity in the value chains that use additives.
5. **Fertilizers.** Chemical and mineral fertilizers consume resources, particularly phosphorus. Regulation to promote smart agriculture, supporting the use of alternative bio-based fertilizers, and enable the development of a sustainable value chain for phosphorus. The regulation should

cover three sources for the creation of a circular loop for phosphorus: manure, wastewater, and solid waste.

Going forward, it is recommended that Turkish policy makers initiate pilot regulations within vital sectors that have strong interrelations and supporting specific industries. The utilization of network analysis should also be broadened to bolster monitoring, reporting, and verification (MRV) objectives. Such a strategic approach will streamline policy implementation and ensure alignment with Sustainable Development Goals, thereby reinforcing Türkiye's trajectory toward a more competitive CE.

Conclusions

Türkiye's CE transition will have economic, trade, and industrial policy implications. The significant opportunities arising from the CE transition will not materialize automatically. For Türkiye to leverage its comparative advantages and retain competitiveness in a changing global economy, policy and investments will need to focus on overcoming existing barriers—such as the existing skill gaps limiting CE investments—and mitigating potentially negative impacts of the transition.

A combination of various policy measures is needed to support the CE transition. A mix of demand-side and supply-side policies will be needed to achieve CE targets. Demand-side measures will be more efficient in reducing the use of non-metallic minerals, while supply-side measures are better suited for increasing recycling of metal ores. Achieving absolute decoupling of resource use from economic growth will be complicated by the high share of non-metallic minerals in Türkiye's resource use patterns. Still, reducing resource use through CE policies intervention will deliver important benefits in terms of climate mitigation, helping Türkiye achieve its NDC objectives.

A strategic approach to the CE transition needs to differentiate between immediate short-term priorities and the longer-term perspective. In the short term, Türkiye needs to speed up the adoption of mature technologies for resource-efficient production, overcome investment hurdles, and improve coordination with the EU and between Turkish stakeholders. In the longer term, Türkiye will need to increase investments in green skills and in raising awareness about the CE, incentivize R&D and new business models, and signal long-term commitment to the CE transition—also in view of catalyzing sufficient private investment, particularly in key industries that support circularity.

Going forward, finalizing and implementing the forthcoming CE Strategy and Action Plan for Türkiye will be essential for the CE transition to unfold in Türkiye. In alignment with the EU's CE Action Plan, Türkiye's new CE Strategy and Action Plan will need to ensure a vast program of regulatory, fiscal, and investment measures. Realistic long-term targets, implemented through concrete short-, medium-, and longer-term actions are essential, also in view of providing investment security for private sector finance. In this respect, a clear MRV system on CE indicators will help ensure the credibility of the CE Strategy and Action Plan.

ANNEX 1: Industries Related to TÜBİTAK's Priority Products and Strongly Related to Them—Industries with Potential for Circularity

N	NAICS4	Industry Description	Economic Sector	Category	In Türkiye (with LQ > 1)[23]
1	2123	Nonmetallic Mineral Mining and Quarrying	Mining and quarrying of non-energy producing products	TÜBİTAK priority	YES
2	3219	Other Wood Product Manufacturing	Wood and of products of wood and cork (except furniture)	TÜBİTAK priority	NO
3	3251	Basic Chemical Manufacturing	Chemicals and pharmaceutical products	TÜBİTAK priority	NO
4	3252	Resin, Synthetic Rubber, and Artificial and Synthetic Fibers and Filaments Manufacturing	Chemicals and pharmaceutical products	TÜBİTAK priority	YES
5	3253	Pesticide, Fertilizer, and Other Agricultural Chemical Manufacturing	Chemicals and pharmaceutical products	TÜBİTAK priority	NO
6	3254	Pharmaceutical and Medicine Manufacturing	Chemicals and pharmaceutical products	TÜBİTAK priority	NO
7	3259	Other Chemical Product and Preparation Manufacturing	Chemicals and pharmaceutical products	TÜBİTAK priority	YES
8	3261	Plastics Product Manufacturing	Rubber and plastics products	TÜBİTAK priority	YES
9	3271	Clay Product and Refractory Manufacturing	Other non-metallic mineral products	TÜBİTAK priority	YES
10	3273	Cement and Concrete Product Manufacturing	Other non-metallic mineral products	TÜBİTAK priority	YES
11	3311	Iron and Steel Mills and Ferroalloy Manufacturing	Manufacture of basic metals	TÜBİTAK priority	YES
12	3312	Steel Product Manufacturing from Purchased Steel	Manufacture of basic metals	TÜBİTAK priority	YES
13	3313	Alumina and Aluminum Production and Processing	Manufacture of basic metals	TÜBİTAK priority	YES
14	3322	Cutlery and Handtool Manufacturing	Fabricated metal products, except machinery and equipment	TÜBİTAK priority	NO
15	3323	Architectural and Structural Metals Manufacturing	Fabricated metal products, except machinery and equipment	TÜBİTAK priority	YES

[23] LQ = Location Quotient. The LQ measures the concentration of a specific industry in a location compared to the overall concentration of that industry in a larger area, such as a country. A higher LQ (greater than 1) means a specific industry is more concentrated in a location, which suggests that related industries tend to group in certain regions. For example, if the textile industry has an LQ of 1.5 in a particular region, it is more concentrated in that region than in others. By identifying key industries in the network, efforts can be focused on making them more sustainable and efficient, which will have a positive ripple effect across connected industries. Overall, the benefits of using network analysis include improved decision-making, better understanding of industry connections, and the ability to identify opportunities for sustainable growth.

N	NAICS4	Industry Description	Economic Sector	Category	In Türkiye (with LQ > 1)[23]
16	3329	Other Fabricated Metal Product Manufacturing	Fabricated metal products, except machinery and equipment	TÜBİTAK priority	YES
1	1111	Oilseed and Grain Farming	Agriculture, forestry and fishing	Highly related	NO
2	1112	Vegetable and Melon Farming	Agriculture, forestry and fishing	Highly related	NO
3	1113	Fruit and Tree Nut Farming	Agriculture, forestry and fishing	Highly related	YES
4	1114	Greenhouse, Nursery, and Floriculture Production	Agriculture, forestry and fishing	Highly related	NO
5	1119	Other Crop Farming	Agriculture, forestry and fishing	Highly related	NO
6	1121	Cattle Ranching and Farming	Agriculture, forestry and fishing	Highly related	NO
7	1122	Hog and Pig Farming	Agriculture, forestry and fishing	Highly related	NO
8	1123	Poultry and Egg Production	Agriculture, forestry and fishing	Highly related	NO
9	1129	Other Animal Production	Agriculture, forestry and fishing	Highly related	NO
10	1133	Logging	Agriculture, forestry and fishing	Highly related	NO
11	2211	Electric Power Generation, Transmission and Distribution	Electricity, gas, water supply, sewerage, waste and remediation services	Highly related	YES
12	3111	Animal Food Manufacturing	Food products, beverages and tobacco	Highly related	NO
13	3112	Grain and Oilseed Milling	Food products, beverages and tobacco	Highly related	YES
14	3113	Sugar and Confectionery Product Manufacturing	Food products, beverages and tobacco	Highly related	YES
15	3114	Fruit and Vegetable Preserving and Specialty Food Manufacturing	Food products, beverages and tobacco	Highly related	YES
16	3115	Dairy Product Manufacturing	Food products, beverages and tobacco	Highly related	YES
17	3118	Bakeries and Tortilla Manufacturing	Food products, beverages and tobacco	Highly related	YES
18	3119	Other Food Manufacturing	Food products, beverages and tobacco	Highly related	YES
19	3121	Beverage Manufacturing	Food products, beverages and tobacco	Highly related	YES
20	3122	Tobacco Manufacturing	Food products, beverages and tobacco	Highly related	NO
21	3131	Fiber, Yarn, and Thread Mills	Textiles, wearing apparel, leather and related products	Highly related	YES
22	3132	Fabric Mills	Textiles, wearing apparel, leather and related products	Highly related	YES

N	NAICS4	Industry Description	Economic Sector	Category	In Türkiye (with LQ > 1)[23]
23	3133	Textile and Fabric Finishing and Fabric Coating Mills	Textiles, wearing apparel, leather and related products	Highly related	NO
24	3141	Textile Furnishings Mills	Textiles, wearing apparel, leather and related products	Highly related	YES
25	3149	Other Textile Product Mills	Textiles, wearing apparel, leather and related products	Highly related	YES
26	3151	Apparel Knitting Mills	Textiles, wearing apparel, leather and related products	Highly related	YES
27	3161	Leather and Hide Tanning and Finishing	Textiles, wearing apparel, leather and related products	Highly related	NO
28	3162	Footwear Manufacturing	Textiles, wearing apparel, leather and related products	Highly related	NO
29	3211	Sawmills and Wood Preservation	Wood and of products of wood and cork (except furniture)	Highly related	NO
30	3212	Veneer, Plywood, and Engineered Wood Product Manufacturing	Wood and of products of wood and cork (except furniture)	Highly related	YES
31	3221	Pulp, Paper, and Paperboard Mills	Paper products and printing	Highly related	YES
32	3222	Converted Paper Product Manufacturing	Paper products and printing	Highly related	YES
33	3231	Printing and Related Support Activities	Paper products and printing	Highly related	YES
34	3241	Petroleum and Coal Products Manufacturing	Coke and refined petroleum products	Highly related	YES
35	3255	Paint, Coating, and Adhesive Manufacturing	Chemicals and pharmaceutical products	Highly related	YES
36	3256	Soap, Cleaning Compound, and Toilet Preparation Manufacturing	Chemicals and pharmaceutical products	Highly related	NO
37	3262	Rubber Product Manufacturing	Rubber and plastics products	Highly related	YES
38	3272	Glass and Glass Product Manufacturing	Other non-metallic mineral products	Highly related	YES
39	3279	Other Nonmetallic Mineral Product Manufacturing	Other non-metallic mineral products	Highly related	YES
40	3314	Nonferrous Metal (except Aluminum) Production and Processing	Manufacture of basic metals	Highly related	YES
41	3315	Foundries	Manufacture of basic metals	Highly related	YES
42	3331	Agriculture, Construction, and Mining Machinery Manufacturing	Machinery and equipment n.e.c.	Highly related	YES
43	3332	Industrial Machinery Manufacturing	Machinery and equipment n.e.c.	Highly related	YES
44	3333	Commercial and Service Industry Machinery Manufacturing	Machinery and equipment n.e.c.	Highly related	YES
45	3336	Engine, Turbine, and Power Transmission Equipment Manufacturing	Machinery and equipment n.e.c.	Highly related	NO

N	NAICS4	Industry Description	Economic Sector	Category	In Türkiye (with LQ > 1)[23]
46	3339	Other General Purpose Machinery Manufacturing	Machinery and equipment n.e.c.	Highly related	NO
47	3341	Computer and Peripheral Equipment Manufacturing	Computer, electronic and optical products	Highly related	NO
48	3342	Communications Equipment Manufacturing	Computer, electronic and optical products	Highly related	YES
49	3343	Audio and Video Equipment Manufacturing	Computer, electronic and optical products	Highly related	NO
50	3344	Semiconductor and Other Electronic Component Manufacturing	Computer, electronic and optical products	Highly related	YES
51	3345	Navigational, Measuring, Electromedical, and Control Instruments Manufacturing	Computer, electronic and optical products	Highly related	NO
52	3351	Electric Lighting Equipment Manufacturing	Electrical equipment	Highly related	YES
53	3352	Household Appliance Manufacturing	Electrical equipment	Highly related	YES
54	3359	Other Electrical Equipment and Component Manufacturing	Electrical equipment	Highly related	NO
55	3362	Motor Vehicle Body and Trailer Manufacturing	Motor vehicles, trailers and semi-trailers	Highly related	YES
56	3364	Aerospace Product and Parts Manufacturing	Other transport equipment	Highly related	NO
57	3365	Railroad Rolling Stock Manufacturing	Other transport equipment	Highly related	NO
58	3366	Ship and Boat Building	Other transport equipment	Highly related	YES
59	3369	Other Transportation Equipment Manufacturing	Other transport equipment	Highly related	NO
60	3399	Other Miscellaneous Manufacturing	Other manufacturing; repair and installation of machinery and equipment	Highly related	YES
61	5111	Newspaper, Periodical, Book, and Directory Publishers	Publishing, audiovisual and broadcasting activities	Highly related	NO
62	5121	Motion Picture and Video Industries	Publishing, audiovisual and broadcasting activities	Highly related	NO
63	5122	Sound Recording Industries	Publishing, audiovisual and broadcasting activities	Highly related	NO
64	5413	Architectural, Engineering, and Related Services	Other business sector services	Highly related	NO

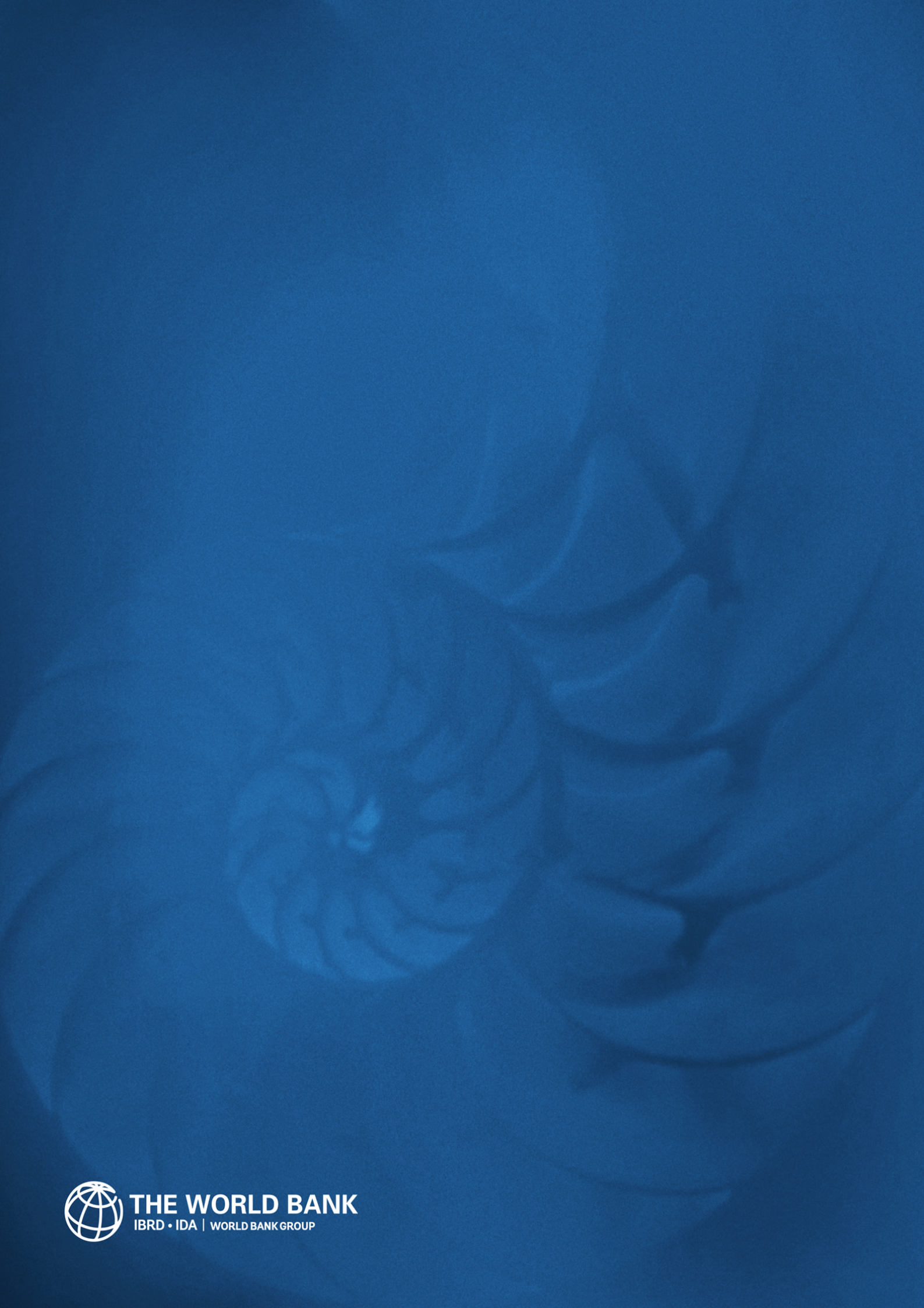
ANNEX 2: Industries (NAICS4) Supporting TÜBİTAK's Priorities and Strongly Related Products

N	NAICS4	Industry Description	Economic Sector	In Türkiye (with LQ > 1)
1	1124	Sheep and Goat Farming	Agriculture, forestry and fishing	NO
2	1132	Forest Nurseries and Gathering of Forest Products	Agriculture, forestry and fishing	NO
3	1153	Support Activities for Forestry	Agriculture, forestry and fishing	NO
4	2213	Water, Sewage and Other Systems	Electricity, gas, water supply, sewerage, waste and remediation services	NO
5	2361	Residential Building Construction	Construction	YES
6	2371	Utility System Construction	Construction	NO
7	2372	Land Subdivision	Construction	NO
8	2373	Highway, Street, and Bridge Construction	Construction	YES
9	2381	Foundation, Structure, and Building Exterior Contractors	Construction	YES
10	2382	Building Equipment Contractors	Construction	YES
11	2383	Building Finishing Contractors	Construction	NO
12	2389	Other Specialty Trade Contractors	Construction	NO
13	3116	Animal Slaughtering and Processing	Food products, beverages and tobacco	NO
14	3117	Seafood Product Preparation and Packaging	Food products, beverages and tobacco	NO
15	3169	Other Leather and Allied Product Manufacturing	Textiles, wearing apparel, leather and related products	YES
16	3274	Lime and Gypsum Product Manufacturing	Other non-metallic mineral products	YES
17	3321	Forging and Stamping	Manufacture of basic metals	YES
18	3324	Boiler, Tank, and Shipping Container Manufacturing	Fabricated metal products, except machinery and equipment	NO
19	3325	Hardware Manufacturing	Fabricated metal products, except machinery and equipment	NO
20	3326	Spring and Wire Product Manufacturing	Fabricated metal products, except machinery and equipment	NO
21	3328	Coating, Engraving, Heat Treating, and Allied Activities	Fabricated metal products, except machinery and equipment	NO

N	NAICS4	Industry Description	Economic Sector	In Türkiye (with LQ > 1)
22	3334	Ventilation, Heating, Air-Conditioning, and Commercial Refrigeration Equipment Manufacturing	Machinery and equipment n.e.c.	YES
23	3335	Metalworking Machinery Manufacturing	Machinery and equipment n.e.c.	YES
24	3353	Electrical Equipment Manufacturing	Electrical equipment	YES
25	3363	Motor Vehicle Parts Manufacturing	Motor vehicles, trailers and semi-trailers	YES
26	3371	Household and Institutional Furniture and Kitchen Cabinet Manufacturing	Other manufacturing; repair and installation of machinery and equipment	NO
27	3372	Office Furniture (including Fixtures) Manufacturing	Other manufacturing; repair and installation of machinery and equipment	YES
28	3379	Other Furniture Related Product Manufacturing	Other manufacturing; repair and installation of machinery and equipment	NO
29	4231	Motor Vehicle and Motor Vehicle Parts and Supplies Merchant Wholesalers	Wholesale and retail trade; repair of motor vehicles	YES
30	4233	Lumber and Other Construction Materials Merchant Wholesalers	Wholesale and retail trade; repair of motor vehicles	YES
31	4235	Metal and Mineral (except Petroleum) Merchant Wholesalers	Wholesale and retail trade; repair of motor vehicles	YES
32	4237	Hardware, and Plumbing and Heating Equipment and Supplies Merchant Wholesalers	Wholesale and retail trade; repair of motor vehicles	YES
33	4238	Machinery, Equipment, and Supplies Merchant Wholesalers	Wholesale and retail trade; repair of motor vehicles	YES
34	4239	Miscellaneous Durable Goods Merchant Wholesalers	Wholesale and retail trade; repair of motor vehicles	YES
35	4244	Grocery and Related Product Merchant Wholesalers	Wholesale and retail trade; repair of motor vehicles	YES
36	4245	Farm Product Raw Material Merchant Wholesalers	Wholesale and retail trade; repair of motor vehicles	NO
37	4246	Chemical and Allied Products Merchant Wholesalers	Wholesale and retail trade; repair of motor vehicles	NO
38	4247	Petroleum and Petroleum Products Merchant Wholesalers	Wholesale and retail trade; repair of motor vehicles	NO
39	4248	Beer, Wine, and Distilled Alcoholic Beverage Merchant Wholesalers	Wholesale and retail trade; repair of motor vehicles	YES
40	4249	Miscellaneous Nondurable Goods Merchant Wholesalers	Wholesale and retail trade; repair of motor vehicles	YES
41	4413	Automotive Parts, Accessories, and Tire Stores	Wholesale and retail trade; repair of motor vehicles	NO
42	4431	Electronics and Appliance Stores	Wholesale and retail trade; repair of motor vehicles	NO
43	4441	Building Material and Supplies Dealers	Wholesale and retail trade; repair of motor vehicles	NO

N	NAICS4	Industry Description	Economic Sector	In Türkiye (with LQ > 1)
44	4451	Grocery Stores	Wholesale and retail trade; repair of motor vehicles	YES
45	4452	Specialty Food Stores	Wholesale and retail trade; repair of motor vehicles	NO
46	4461	Health and Personal Care Stores	Wholesale and retail trade; repair of motor vehicles	NO
47	4471	Gasoline Stations	Wholesale and retail trade; repair of motor vehicles	YES
48	4483	Jewelry, Luggage, and Leather Goods Stores	Wholesale and retail trade; repair of motor vehicles	NO
49	4831	Deep Sea, Coastal, and Great Lakes Water Transportation	Transportation and storage	NO
50	4841	General Freight Trucking	Transportation and storage	NO
51	4851	Urban Transit Systems	Transportation and storage	NO
52	4883	Support Activities for Water Transportation	Transportation and storage	NO
53	4911	Postal Service	Transportation and storage	NO
54	5182	Data Processing, Hosting, and Related Services	IT and other information services	NO
55	5311	Lessors of Real Estate	Real estate activities	NO
56	5313	Activities Related to Real Estate	Real estate activities	NO
57	5418	Advertising, Public Relations, and Related Services	Other business sector services	YES
58	5619	Other Support Services	Other business sector services	NO
59	5621	Waste Collection	Other business sector services	NO
60	5622	Waste Treatment and Disposal	Other business sector services	NO
61	5629	Remediation and Other Waste Management Services	Other business sector services	NO
62	6213	Offices of Other Health Practitioners	Human health and social work	NO
63	6219	Other Ambulatory Health Care Services	Human health and social work	YES
64	6231	Nursing Care Facilities (Skilled Nursing Facilities)	Human health and social work	NO
65	6233	Continuing Care Retirement Communities and Assisted Living Facilities for the Elderly	Human health and social work	NO
66	6241	Individual and Family Services	Human health and social work	NO

N	NAICS4	Industry Description	Economic Sector	In Türkiye (with LQ > 1)
67	7111	Performing Arts Companies	Arts, entertainment, recreation and other service activities	NO
68	7112	Spectator Sports	Arts, entertainment, recreation and other service activities	NO
69	7211	Traveler Accommodation	Accomodation and food services	YES
70	7212	RV (Recreational Vehicle) Parks and Recreational Camps	Accomodation and food services	YES
71	7225	Restaurants and Other Eating Places	Accomodation and food services	YES
72	8111	Automotive Repair and Maintenance	Motor vehicles, trailers and semi-trailers	NO
73	8113	Commercial and Industrial Machinery and Equipment (except Automotive and Electronic) Repair and Maintenance	Other manufacturing; repair and installation of machinery and equipment	NO
74	8114	Personal and Household Goods Repair and Maintenance	Other business sector services	NO
75	8123	Drycleaning and Laundry Services	Human health and social work	NO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