



## Sectoral Transformation and Financial Fragility in the Turkish Economy:

### A Sector-Level Panel Analysis, 2009–2023

Yasir KÜÇÜKŞAHİN<sup>1</sup>

#### Abstract

This study examines the structural transformation and financial fragility of seventeen main sectors in the Turkish economy between 2009 and 2023, a period encompassing three distinct macroeconomic shocks: the 2018 currency and credit crisis, the 2020 COVID-19 pandemic, and the post-2021 inflation episode. Drawing on sector-level balance sheet data compiled by the Central Bank of the Republic of Türkiye, the analysis constructs a composite fragility score combining leverage, short-term debt dependence, liquidity, and profitability, and traces its evolution through sector fixed-effects panel regressions. The findings reveal pronounced divergence in real asset growth across sectors: agriculture, manufacturing, and trade expanded in real terms, whereas professional services, real estate, and mining contracted. Manufacturing, transport, and mining display the most resilient financial profiles, while education, arts and recreation, and accommodation are the most fragile. The econometric estimates indicate that the strongest and most statistically robust effect of macroeconomic shocks operates through the liquidity channel: the 2018 currency crisis reduced the sectoral current ratio by 0.37 points, with the COVID-19 and inflation shocks producing further significant deterioration. The results underscore that liquidity, rather than leverage, was the principal margin along which Turkish sectors absorbed successive macroeconomic shocks.

**Keywords:** financial fragility; sectoral analysis; panel data; Turkish economy; corporate liquidity; macroeconomic shocks

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#### Introduction

Between 2009 and 2023 the Turkish economy moved through one of the most turbulent macroeconomic sequences in its recent history. The rapid recovery that followed the global financial crisis, sustained by abundant global liquidity and historically low international interest rates, gave way in 2018 to a severe currency and credit crisis during which the lira lost roughly 40 percent of its value against the US dollar. Two years later the COVID-19 pandemic delivered a simultaneous demand and supply shock, and from 2021 onward the economy entered an extraordinary inflationary phase, with consumer price inflation peaking above 70 percent in 2022. Because each of these shocks transmitted through different channels—balance sheet revaluation, liquidity withdrawal, and the erosion of real values—their consequences for the corporate sector were neither uniform nor easily summarised by aggregate statistics.

<sup>1</sup> Dr., Harran University, Department of Economics, [yasirkn@harran.edu.tr](mailto:yasirkn@harran.edu.tr), ORCID: 0000-0002-2534-4278

Determining which sectors expanded and which contracted in real terms, how financial fragility evolved over this period, and through which channels macroeconomic shocks reached corporate balance sheets is a question of both academic and policy relevance. The vulnerability of the Turkish corporate sector—its high reliance on short-term financing, its accumulated foreign currency exposure, and its thin equity buffers—has been widely discussed, yet most of this discussion rests on either firm-level samples or macro-level aggregates. The intermediate, sector-level perspective, which connects macroeconomic developments to the structural characteristics of individual industries and speaks directly to sectoral policy design, has received comparatively little attention.

This paper addresses that gap. Using sector-level balance sheet data organised under the NACE Rev. 2 classification and aggregated to seventeen main sectors, it constructs a panel covering the years 2009 to 2023 and poses three questions. First, how did the real asset base of the main sectors evolve over the period, and which sectors grew or contracted? Second, how is financial fragility—measured by a composite index spanning leverage, maturity structure, liquidity, and profitability—distributed across sectors and over time? Third, to what extent did the three major macroeconomic shocks affect sectoral financial conditions, and through which channel did this effect primarily operate?

The principal findings are as follows. After adjusting for cumulative consumer price inflation, agriculture, manufacturing, and trade recorded positive real asset growth, while professional services, real estate, mining, and transport contracted in real terms. In terms of composite fragility, manufacturing, transport, and mining emerge as the most resilient sectors, whereas education, arts and recreation, and accommodation rank as the most fragile. The panel estimates show that the strongest and most statistically robust effect of macroeconomic shocks operates through liquidity: the 2018 currency crisis significantly reduced the sectoral current ratio, with the pandemic and inflation episodes inflicting further significant deterioration. Effects on leverage and profitability, by contrast, are statistically indistinguishable from zero at the aggregate level, indicating that liquidity was the principal margin of adjustment.

The remainder of the paper is organised as follows. Section 2 reviews the related literature. Section 3 describes the data, the cleaning procedure, and the construction of the fragility index. Section 4 sets out the empirical strategy. Section 5 presents the results, and Section 6 concludes.

## **Literature Review**

The analytical foundations of financial fragility rest on the proposition, advanced by Minsky (1986), that prolonged periods of economic expansion encourage a progressive shift from hedged toward speculative and ultimately Ponzi financing structures, rendering economies endogenously fragile. Kiyotaki and Moore (1997) formalised a complementary mechanism in which fluctuations in asset values interact with collateral constraints to generate persistent credit cycles, while Bernanke, Gertler and Gilchrist (1999) showed through the financial accelerator that informational frictions amplify the macroeconomic consequences of shocks. These frameworks share a common implication that is central to the present study: macroeconomic disturbances do not affect firms uniformly but are mediated by the structure of their balance sheets. The modern theory of capital structure provides the microeconomic counterpart to this view. Beginning with the irrelevance theorem of Modigliani and Miller (1958), the literature progressively introduced the market imperfections—bankruptcy costs in the trade-off theory of Myers (1984), adverse selection in the pecking-order model of Myers and Majluf (1984), and agency conflicts in Jensen and Meckling (1976)—that make financing structure consequential for firm value and resilience. Among the empirical regularities to emerge from this tradition, the protective role of firm size is among the most robust: Rajan and Zingales (1995) and Frank and Goyal (2009) document that larger firms exhibit systematically lower distress probabilities, a finding that recurs throughout the emerging-market literature. The measurement of distress itself owes much to Altman (1968), whose multivariate discriminant approach established the practice of combining several balance sheet ratios into a single index, a logic that continues to inform contemporary distress-scoring applications across industries and countries (see the reviews and applications surveyed by recent work in emerging markets). A distinct strand of the literature concerns the special vulnerabilities of emerging-market corporates, where exchange rate volatility interacts with balance sheet composition. Eichengreen and Hausmann (1999) identified the inability of emerging economies to borrow abroad in their own

currency—the problem of “original sin”—as a structural source of fragility, and Bleakley and Cowan (2008) demonstrated that the balance sheet damage from depreciation depends critically on whether firms hold offsetting foreign-currency assets. Claessens, Djankov and Xu (2000), studying the East Asian crisis, established that pre-crisis leverage and short-term debt dependence were the primary determinants of subsequent performance deterioration—a result of direct relevance to the Turkish case, where short-term liabilities dominate corporate financing. Alfaro, Asis, Chari and Panizza (2019), examining corporate balance sheets across emerging markets after the global financial crisis, found that firm size and currency mismatch jointly govern the transmission of exchange rate shocks to financial fragility, with large and highly leveraged firms proving most vulnerable to depreciation. More recent contributions have extended this analysis to the pandemic period: studies of the COVID-19 shock consistently find that it operated primarily through the liquidity channel, eroding firms’ cash positions and raising rollover risk, with effects concentrated in sectors most exposed to demand disruption and least able to access external finance. The Turkish experience occupies a prominent place within this literature. Following the 2000–2001 banking and currency crisis analysed by Özatay and Sak (2002), the financial system was substantially restructured, yet the structural vulnerabilities catalogued by Reinhart and Rogoff (2009)—dependence on external financing, short debt maturities, and exposure to sudden stops—remained embedded in corporate balance sheets. A growing body of work on the 2018 turbulence documents how the foreign currency exposure of non-financial corporates, accumulated during the low-interest-rate environment of the 2010s, magnified the balance sheet impact of the lira’s depreciation and triggered widespread debt restructuring across construction, energy, and transportation. Despite the richness of this evidence, systematic sector-level analysis that spans an entire business cycle and incorporates the successive shocks of 2018, 2020, and 2022 remains absent. The present study contributes to the literature by providing such an analysis, combining a multidimensional fragility index with a panel research design to identify the channel through which macroeconomic shocks have most consistently affected Turkish sectors.

## **Data**

The empirical analysis draws on sector-level financial statements compiled by the Central Bank of the Republic of Türkiye (CBRT) and published in its Sector Balance Sheets (Sektörel Bilançolar) dataset under the NACE Rev. 2 industrial classification. These statements aggregate the audited balance sheets and income statements of registered non-financial enterprises. The raw data span the years 2009 to 2023 at annual frequency and cover several hundred narrowly defined sub-sectors.

Inspection of the raw data revealed a systematic measurement problem: in a substantial share of sector-year cells, individual balance sheet items were recorded at values four to five orders of magnitude larger than their economically plausible level. These errors were idiosyncratic at the cell level, appearing as isolated spikes within otherwise smoothly evolving sub-sector time series; a sub-sector whose total assets grew steadily around  $10^{11}$  might exhibit a single year recorded near  $10^{16}$ . To address this, each balance sheet item was screened within its own sub-sector time series, and any cell exceeding the sub-sector's median order of magnitude by more than two factors of ten was treated as corrupt and set to missing. This procedure preserves the genuine growth path of each series while removing only the isolated erroneous observations. Ratios computed from cleaned items were additionally bounded to economically meaningful ranges. Across the raw panel, this screen flagged approximately 38 percent of sector-year cells as corrupt. Because the spikes were idiosyncratic rather than concentrated in any single statement item, they were distributed broadly across asset, liability, and income components rather than affecting one variable disproportionately. Since the screen removes only isolated cells while leaving the surrounding growth path intact, and since the subsequent aggregation to main sectors relies on medians (Section 3), the cleaned series and the fragility measures derived from them are insensitive to the precise cut-off applied.

The analysis is conducted at the level of seventeen NACE main sectors rather than the several hundred sub-sectors. This choice reflects two considerations. The main-sector level is the more meaningful and interpretable unit for the structural and policy questions at hand; and, following cell-level cleaning, sub-sector ratios are aggregated to the main-sector level by taking medians, which

provides robustness to any remaining outliers. The resulting panel comprises seventeen sectors observed over fifteen years.

Four ratios capture distinct dimensions of financial condition: the debt ratio (total liabilities to total assets), the short-term debt share (short-term to total liabilities), the current ratio (current assets to short-term liabilities), and return on assets (net income to total assets). These correspond respectively to solvency, maturity structure, liquidity, and profitability. From them a composite fragility score ranging from zero to four is constructed, adding one point for each of the following conditions: a debt ratio above 0.60 (liabilities exceeding 60 percent of assets); a short-term debt share above 0.60 (the majority of debt being short-term, indicating rollover risk); a current ratio below 1.0 (current assets failing to cover short-term liabilities); and negative return on assets (an operating loss). Inspired by the multivariate logic of Altman (1968), this index summarises in a single interpretable measure the several dimensions of vulnerability that no individual ratio captures alone; the equal weighting of the four components reflects the absence of a theoretical basis for privileging one dimension over another at the sector level. The two 0.60 cut-offs are not arbitrary. For the debt ratio, a value above 0.60 marks the point at which liabilities exceed sixty percent of assets and the equity buffer falls below forty percent; this lies within the conventional band used to flag elevated leverage in the corporate-distress literature and sits just below the sample mean of 0.63 (Table 1), so that the indicator isolates the more leveraged sectors without being triggered mechanically across the whole panel. For the short-term debt share, a value above 0.60 identifies sectors in which the majority of liabilities mature within one year and must be rolled over continuously; short-term debt dependence of this kind is identified by Claessens, Djankov and Xu (2000) as a primary determinant of distress during crises, a consideration of direct relevance to the Turkish case, where the share averages 0.73. The remaining two components rest on standard accounting benchmarks: a current ratio below 1.0, the conventional threshold at which current assets no longer cover short-term liabilities, and a negative return on assets, which denotes an outright operating loss. Table 1 reports descriptive statistics. The average fragility score of 2.02, together with a short-term debt share averaging 0.73, identifies maturity mismatch as the most pervasive structural feature of the Turkish corporate sector over the period.

**Table 1**  
*Descriptive Statistics (Main-Sector Panel, 2009–2023)*

Variable	Mean	SD	Min	Max	N
Debt ratio (liabilities/assets)	0.626	0.343	0.00	4.07	239
Short-term debt share	0.733	0.200	0.00	1.00	254
Current ratio	1.086	1.004	0.00	12.40	253
Return on assets (ROA)	0.021	0.110	−0.53	0.95	246
Composite fragility score (0–4)	2.020	0.982	0	4	255

*Notes:* Ratios are computed as medians of the sub-sectors within each main sector. The fragility score is the sum of four binary indicators (range 0–4).

## Empirical Strategy

The empirical analysis employs sector fixed-effects panel regression, a specification that controls for all time-invariant sectoral characteristics—industrial structure, capital intensity, and regulatory environment—and thereby isolates the within-sector effect of macroeconomic shocks. The transparency and parsimony of this single method are appropriate for a panel of seventeen sectors, where heavily parameterised models would strain the available degrees of freedom. The estimated equation is

$$y_{it} = \alpha_i + \beta_1 \cdot FX_t + \beta_2 \cdot COVID_t + \beta_3 \cdot INFL_t + \varepsilon_{it},$$

where  $y_{it}$  denotes the financial indicator of sector  $i$  in year  $t$ —the composite fragility score, the current ratio, the debt ratio, or return on assets— $\alpha_i$  captures sector fixed effects, and  $FX$ ,  $COVID$ , and  $INFL$  are indicator variables for 2018, 2020, and the 2022–2023 period, respectively. Standard errors are clustered at the sector level to accommodate within-sector serial correlation. The choice between fixed and

random effects was evaluated using the Hausman (1978) test, which favoured the fixed-effects estimator.

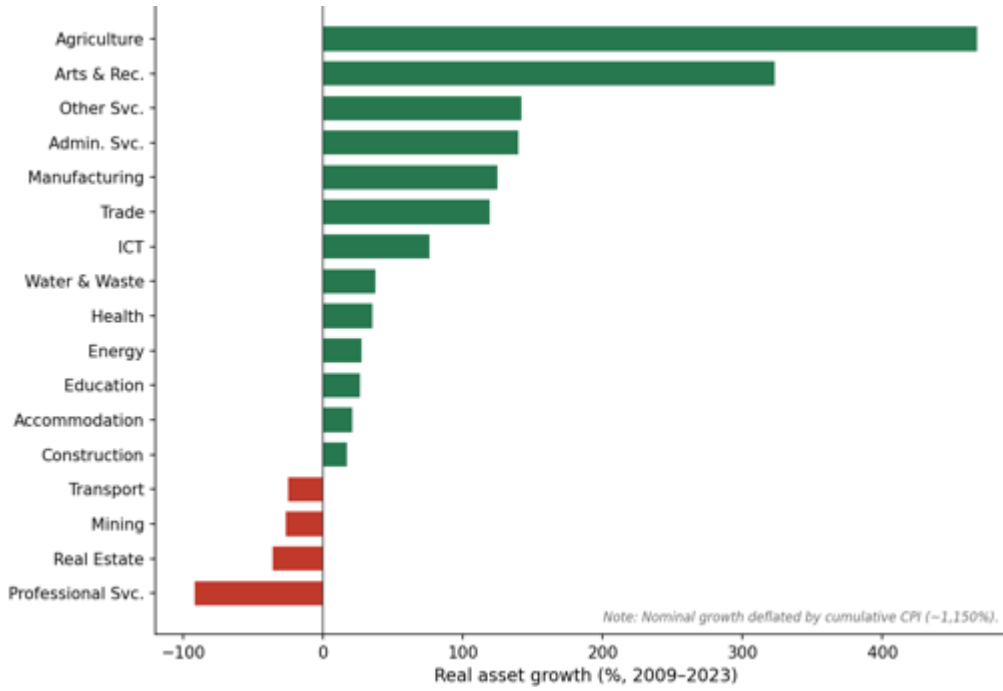
Because the explanatory variables are common annual shocks, the within-sector  $R^2$  of such a specification is mechanically modest: by construction, the fixed effects absorb the large and persistent differences in financial structure across sectors, leaving only the comparatively small year-to-year variation for the shock indicators to explain. The economically meaningful measure of fit is therefore the overall  $R^2$  of the full model including sector effects, which captures the substantial cross-sectional heterogeneity in fragility documented below. For the fragility score this overall  $R^2$  reaches 0.24, indicating that sectoral structure and the shock indicators jointly account for roughly a quarter of the total variation in fragility—a level consistent with comparable sector-level studies. What matters for the present argument, however, is not the share of variance explained but the identification of the channel through which shocks operate, to which the analysis now turns.

## **Results**

### **Real Sectoral Transformation**

Figure 1 presents real asset growth by sector over 2009–2023, obtained by deflating nominal growth by the cumulative rise in consumer prices, which exceeded 1,100 percent over the period. This adjustment is essential: in a high-inflation environment, nominal figures convey little information about genuine sectoral expansion. The results reveal a sharp divergence. Agriculture and arts and recreation recorded the strongest real growth, while manufacturing, trade, and information and communication technologies posted moderate positive real growth. That manufacturing—the largest sector by assets throughout the period—maintained positive real growth indicates that the industrial base preserved its real scale despite the inflationary turbulence. By contrast, professional services, real estate, mining, and transport contracted in real terms. The pronounced real contraction of professional services is particularly notable, reflecting nominal asset values that fell far behind the price level.

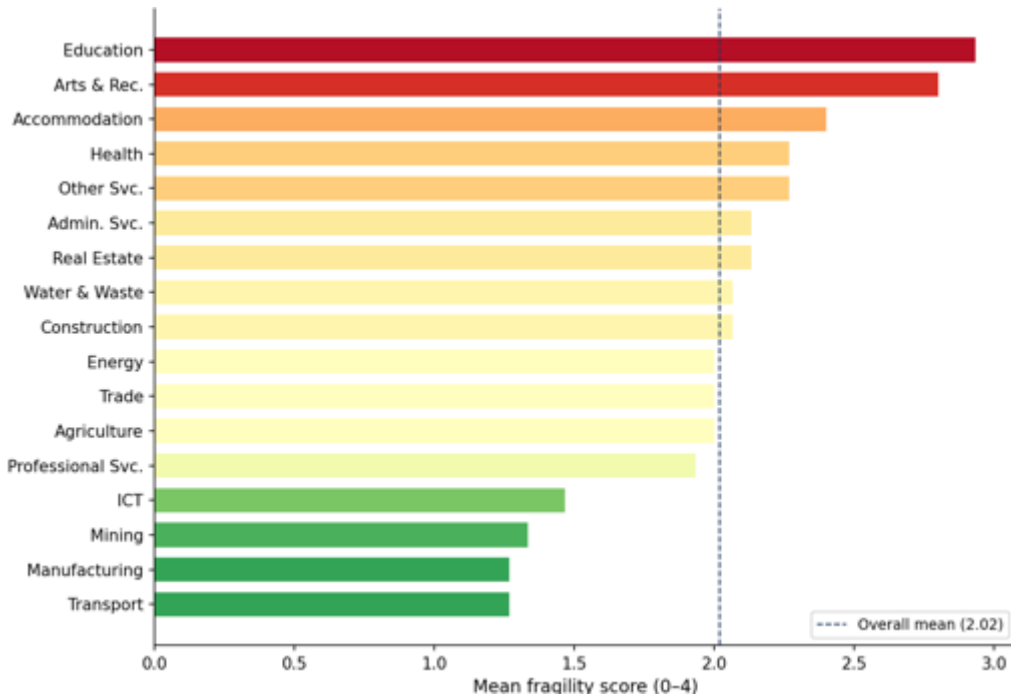
**Figure 1.** Real Asset Growth by Sector, 2009-2023



### The Distribution of Financial Fragility

Figure 2 and Table 2 report average fragility by sector. Manufacturing, transport, and mining exhibit the lowest fragility scores, supported by relatively strong liquidity and positive profitability. At the opposite extreme, education, arts and recreation, and accommodation record the highest fragility, characterised by weak liquidity and recurrent losses. The decomposition of the index is instructive: manufacturing combines high maturity mismatch with strong liquidity and positive returns, so that its overall fragility remains low, whereas education scores highly on nearly every dimension. This heterogeneity confirms that sectoral fragility cannot be summarised by any single ratio and motivates the composite approach.

**Figure 2.** Average Financial Fragility by Sector, 2009-2023



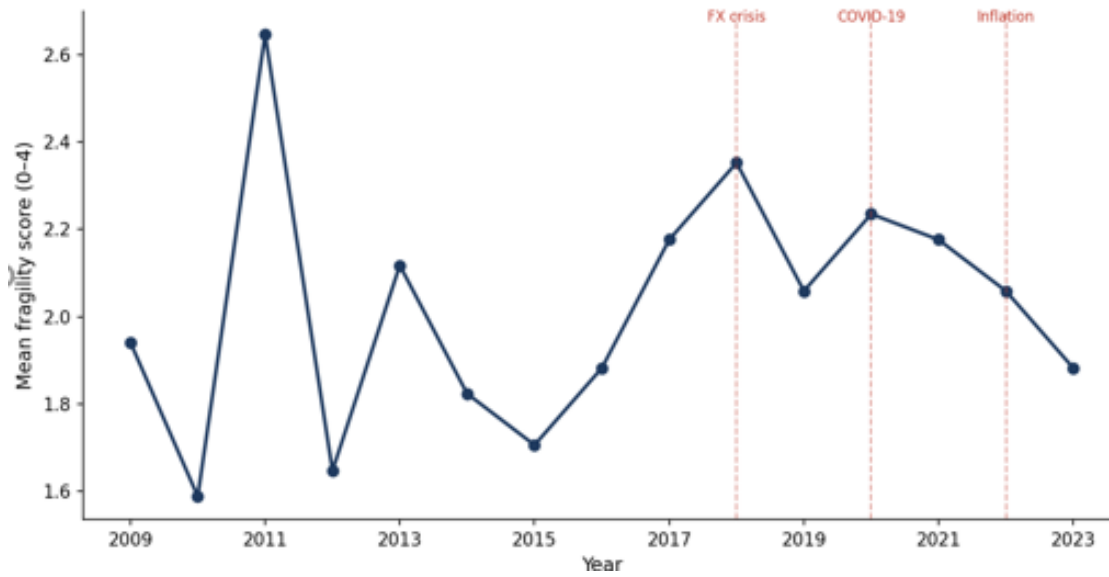
**Table 2**  
*Average Fragility and Financial Indicators by Sector*

Sector	Fragility	Debt ratio	ST share	Current r.	ROA
Education	2.93	0.71	0.81	0.74	0.01
Arts & Recreation	2.80	0.79	0.73	0.73	-0.03
Accommodation	2.40	0.62	0.75	0.80	-0.00
Health	2.27	0.64	0.76	0.94	0.03
Other Services	2.27	0.66	0.87	1.07	0.01
Admin. Services	2.13	0.62	0.79	1.17	0.01
Real Estate	2.13	0.54	0.77	0.05	-0.00
Water & Waste	2.07	0.66	0.83	1.09	0.01
Construction	2.07	0.75	0.88	1.12	0.01
Energy	2.00	0.63	0.60	0.87	0.01
Trade	2.00	0.67	0.87	1.27	0.02
Agriculture	2.00	0.59	0.75	1.16	0.01
Professional Services	1.93	0.54	0.90	1.01	0.01
ICT	1.47	0.56	0.83	1.26	0.02
Mining	1.33	0.53	0.63	1.07	0.05
Transport	1.27	0.60	0.45	1.02	0.03
Manufacturing	1.27	0.58	0.78	1.37	0.04

Notes: Fragility is the period mean; remaining columns are period medians. ST share = short-term debt share.

The temporal dimension is displayed in Figure 3, which plots average fragility across years, and in Figure 4, which presents the full sector-by-year fragility matrix. The aggregate series fluctuates between 1.9 and 2.7, with local peaks around 2011, 2017, and 2019. The heat map in Figure 4 conveys the underlying detail: education and arts and recreation remain persistently fragile throughout the period, manufacturing remains consistently resilient, and the columns corresponding to the shock years—outlined in the figure—show a visible intensification of fragility across a broad range of sectors, most clearly in 2018.

**Figure 3.** Evolution of Average Financial Fragility



**Figure 4.** Financial Fragility Score by Sector and Year, 2009–2023

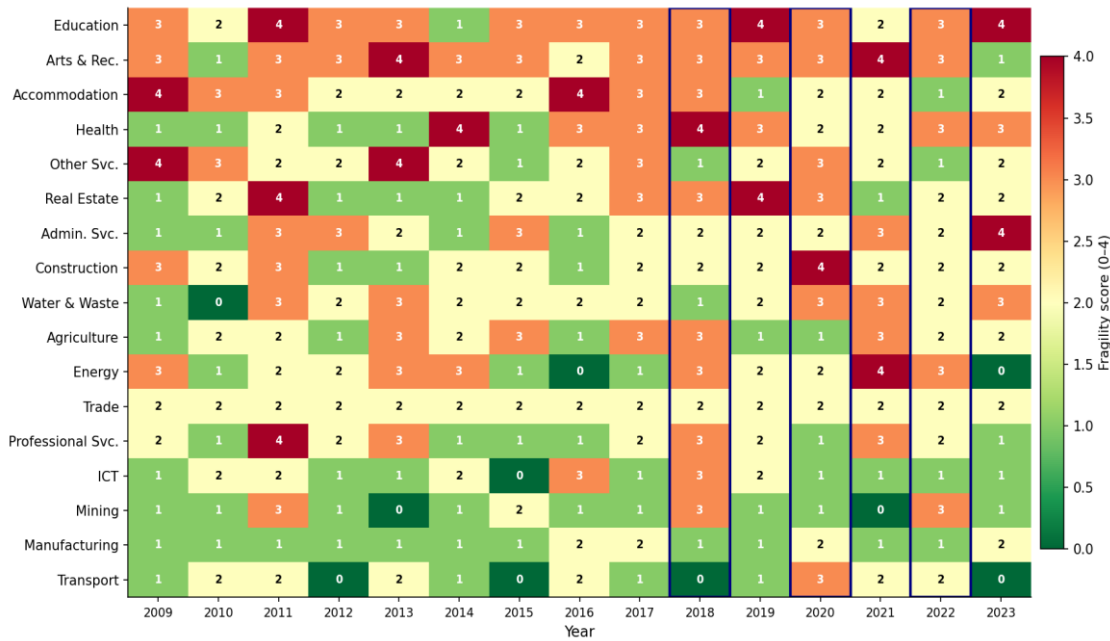


Figure 4 is especially revealing for the cross-sectoral propagation of shocks. The 2018 currency crisis is associated with elevated fragility in sectors as varied as health, real estate, energy, and professional services, consistent with the broad-based nature of that episode. Manufacturing, transport, and mining retain comparatively low scores even in the crisis years, underscoring the structural resilience conferred by their stronger liquidity positions.

### The Effect of Macroeconomic Shocks

Table 3 reports the fixed-effects estimates for the four financial indicators. The central finding is that the effect of macroeconomic shocks operates most strongly and most robustly through the liquidity channel. In the current-ratio specification, all three shocks enter with negative and statistically significant coefficients. The 2018 currency crisis reduced the sectoral current ratio by 0.368 points ( $p < 0.01$ ), the largest liquidity contraction in the sample; the COVID-19 shock lowered it by 0.240 points ( $p < 0.10$ ) and the inflation episode by 0.239 points ( $p < 0.05$ ). This pattern indicates that successive macroeconomic shocks compressed the capacity of Turkish sectors to cover their short-term obligations from current assets, with the currency crisis inflicting the sharpest damage.

**Table 3**

*Fixed-Effects Estimates: Macroeconomic Shocks and Sectoral Financial Conditions*

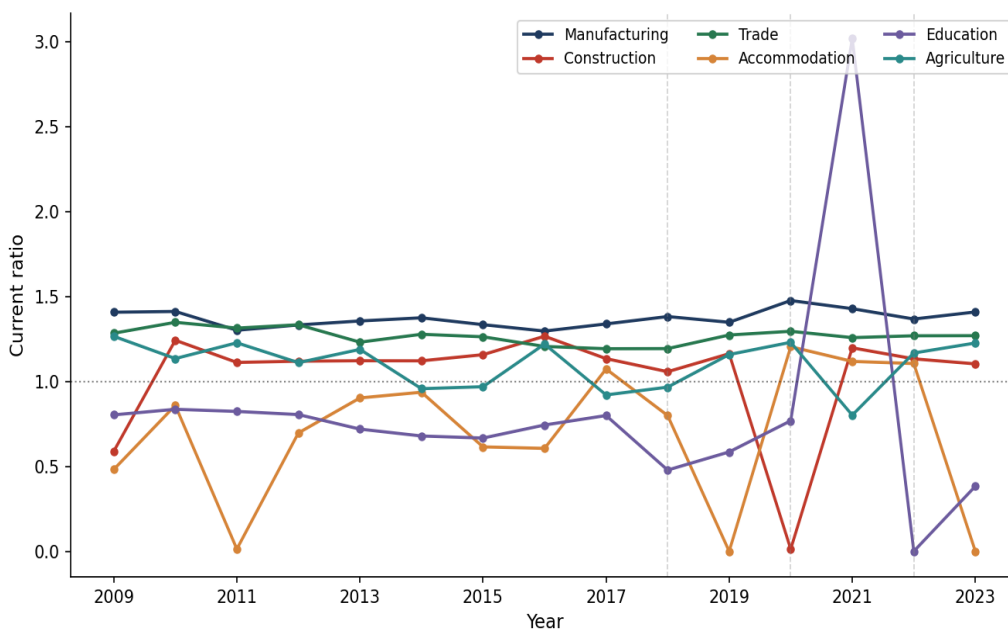
	Fragility	Current ratio	Debt ratio	ROA
FX crisis (2018)	0.374 (0.248)	-0.368*** (0.115)	-0.002 (0.052)	-0.008 (0.014)
COVID-19 (2020)	0.257 (0.208)	-0.240* (0.128)	0.167 (0.116)	-0.003 (0.015)
Inflation (2022–23)	-0.008 (0.163)	-0.239** (0.102)	-0.004 (0.047)	0.013 (0.037)
Sector fixed effects	Yes	Yes	Yes	Yes
Observations	255	253	239	246
<b>R<sup>2</sup> (overall)</b>	<b>0.237</b>	<b>0.083</b>	<b>0.141</b>	<b>0.067</b>

Notes: Sector-clustered standard errors in parentheses. All specifications include sector fixed effects. R<sup>2</sup> is the overall coefficient of determination of the full model. \*  $p < 0.10$ , \*\*  $p < 0.05$ , \*\*\*  $p < 0.01$ .

By contrast, the shock coefficients in the debt-ratio and return-on-assets specifications are statistically indistinguishable from zero. This is itself informative: it suggests that the effects of shocks on leverage and profitability were heterogeneous across sectors and offsetting in aggregate, so that no systematic average effect emerges. The leverage result is consistent with the competing mechanisms identified in the emerging-market literature, in which currency depreciation simultaneously inflates the domestic value of assets and liabilities while inducing deleveraging, producing ambiguous net effects on measured leverage. The coefficients on the composite fragility score are positive for the currency and pandemic shocks—indicating a tendency for fragility to rise—but do not attain conventional significance in the seventeen-sector panel, a reflection of the limited degrees of freedom rather than an absence of economic effect. Taken together, the estimates point to liquidity as the principal margin along which Turkish sectors absorbed the macroeconomic shocks of the period.

Figure 5 corroborates the econometric evidence. The current ratio of manufacturing remains stably above unity throughout the period, whereas accommodation, education, and construction display sharp swings and recurrent declines below one during the shock years. The visual evidence reinforces the conclusion that liquidity was both the most affected dimension of financial condition and the dimension along which sectors differed most sharply in their resilience.

**Figure 5.** Liquidity (Current Ratio) for Selected Sectors



## Discussion and Conclusion

This paper has analysed the structural transformation and financial fragility of seventeen main sectors of the Turkish economy between 2009 and 2023, a period marked by three successive macroeconomic shocks. Three conclusions stand out. First, real asset growth diverged sharply across sectors: agriculture, manufacturing, and trade expanded in real terms, while professional services, real estate, and mining contracted. Second, financial fragility was highly heterogeneous, with manufacturing, transport, and mining proving most resilient and education, accommodation, and arts and recreation most fragile—a pattern that persisted across the entire period and intensified visibly during the shock years. Third, the econometric analysis identifies liquidity as the principal channel through which macroeconomic shocks affected sectoral balance sheets: the 2018 currency crisis, in particular, significantly compressed the sectoral current ratio, with the pandemic and inflation episodes producing further significant deterioration, whereas effects on leverage and profitability were not systematic in aggregate.

These findings carry clear policy implications. Because shocks transmitted primarily through liquidity rather than leverage, support mechanisms deployed during periods of stress—credit guarantee schemes and temporary liquidity facilities—are most effective when directed at reinforcing sectoral

liquidity buffers. In practice this implies prioritising instruments that act directly on the current ratio—revolving credit-guarantee lines, short-maturity working-capital facilities, and temporary tax and social-security deferrals—over measures aimed at reducing leverage, and calibrating their scale and eligibility to the sectors whose current ratio falls persistently below one during shock years, such as accommodation, education, and construction. Because the liquidity contraction was sharpest during the 2018 currency crisis, facilities of this kind deliver the greatest benefit when activated pre-emptively at the onset of currency stress rather than once rollover difficulties have already materialised. The concentration of fragility in service sectors such as education, accommodation, and arts and recreation argues for sector-specific design rather than uniform measures. The study is subject to limitations that suggest avenues for further work. The main-sector level of aggregation conceals within-sector firm heterogeneity, and although the cell-level cleaning procedure addresses the measurement problems in the raw data, it reduces the number of usable observations for some smaller sectors. Future research could enrich the present design with firm-level data and with continuous macroeconomic indicators—exchange rates, inflation, and policy interest rates—in place of discrete shock indicators.

**Ethical Approval:** This study uses publicly available, aggregated secondary data and therefore falls outside the scope of ethics committee approval.

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### Appendix A. Sector Classification

Table A1 lists the seventeen NACE Rev. 2 sections that constitute the main sectors analysed in this study, together with the short labels used in the tables and figures above.

**Table A1**

*NACE Rev. 2 Main Sectors Used in the Analysis*

NACE	NACE Rev. 2 section (official title)	Label used in this study
A	Agriculture, forestry and fishing	Agriculture
B	Mining and quarrying	Mining
C	Manufacturing	Manufacturing
D	Electricity, gas, steam and air conditioning supply	Energy
E	Water supply; sewerage, waste management and remediation	Water & Waste
F	Construction	Construction
G	Wholesale and retail trade	Trade
H	Transportation and storage	Transport
I	Accommodation and food service activities	Accommodation
J	Information and communication	ICT
L	Real estate activities	Real Estate
M	Professional, scientific and technical activities	Professional Services
N	Administrative and support service activities	Admin. Services
P	Education	Education
Q	Human health and social work activities	Health
R	Arts, entertainment and recreation	Arts & Recreation
S	Other service activities	Other Services

*Notes: Financial and insurance activities (Section K), public administration and defence (Section O), and the activities of households (T) and extraterritorial organisations (U) are excluded, consistent with the non-financial corporate coverage of the dataset.*