

DETERMINANTS OF THE SHADOW ECONOMY IN TÜRKİYE: THE ROLE OF INNOVATION, GOVERNMENT QUALITY, GOVERNMENT SIZE, AND INFLATION

Türkiye’de Kayıt Dışı Ekonomiyi Belirleyen Faktörler: İnovasyon, Hükümet Kalitesi, Kamu Kesimi Büyüklüğü ve Enflasyonun Rolü

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Abstract

Global economies are negatively impacted by the shadow economy, and hence, many governments have been increasingly trying to combat it in recent years. Considering the crucial importance of limiting the size of the shadow economy and the factors influencing it, the primary goal of this study is to investigate how innovation, government size, government quality, and inflation affect the shadow economy in Türkiye. To achieve the study’s objectives, we employ Fourier Shin cointegration and Fourier-based DOLS tests, covering the period from 1990 to 2020. The findings of the study indicate that the effects of innovation, government size, and government quality on the shadow economy are negative and statistically significant. However, inflation affects the shadow economy positively and significantly. Therefore, policymakers should allocate greater resources within the government size to combat the shadow economy in Türkiye, while simultaneously increasing policies that promote innovation, improving government quality, and maintaining macroeconomic stability by controlling inflation more effectively.

Keywords:

Shadow Economy,
Government Quality,
Government Size,
Innovation.

JEL Codes:

O17, E31,
O30, H50.

Anahtar Kelimeler:

Kayıt Dışı Ekonomi,
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İnovasyon.

JEL Kodları:

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Öz

Kayıt dışı ekonomi, küresel ekonomileri olumsuz etkilemekte olup, bu nedenle birçok hükümet son yıllarda kayıt dışı ekonomiyle mücadelede giderek daha fazla önem vermektedir. Kayıt dışı ekonominin boyutunun sınırlandırılmasının ve onu etkileyen faktörlerin belirlenmesinin kritik önemi dikkate alındığında, bu çalışmanın temel amacı inovasyon, kamu kesimi büyüklüğü, kamu kalitesi ve enflasyonun Türkiye’de kayıt dışı ekonomi üzerindeki etkilerini incelemektir. Bu amaç doğrultusunda, 1990–2020 dönemini kapsayan veri seti kullanılarak Fourier Shin eşbütünleşme testi ve Fourier tabanlı DOLS yöntemi uygulanmıştır. Çalışmanın bulguları, inovasyonun, kamu kesimi büyüklüğünün ve kamu kalitesinin kayıt dışı ekonomi üzerinde negatif ve istatistiksel olarak anlamlı etkilerinin olduğunu göstermektedir. Buna karşılık, enflasyonun kayıt dışı ekonomi üzerinde pozitif ve anlamlı bir etkisi bulunmaktadır. Bu doğrultuda, politika yapıcıların Türkiye’de kamu kesimi büyüklüğü içinde kayıt dışı ekonomiyle mücadelede daha fazla kaynak ayırmaları; aynı zamanda inovasyonu teşvik edici politikaları artırmaları, kamu kalitesini iyileştirmeleri ve enflasyonu daha etkin şekilde kontrol ederek makroekonomik istikrarı sağlamaları gerekmektedir.

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1. Introduction

The shadow economy (henceforth SE) has been influential and widespread in numerous countries worldwide for many years. Consequently, a substantial body of academic literature investigates the SE from a variety of aspects (Zolkover and Terziev, 2020). The consistently large size of the SE in numerous countries is a primary factor that keeps it a significant subject of research. Although the size of the SE has been declining over time, global estimates indicate it was, on average and as a percentage of official GDP, 35.2% in 2002/2003 (Schneider, 2005), 32% from 1984 to 2006 (Alm and Embaye, 2013), 31.0% in 2007 (Schneider et al., 2010b), 17.1% from 1999 to 2007 (Buehn and Schneider, 2012), 33.7% from 1999 to 2013 (Hassan and Schneider, 2016), and 31.9% between 1991 and 2015 (Medina and Schneider, 2018). Furthermore, the estimations show that the size of the SE differs across individual nations as well as between certain country groups. Numerous estimates indicate that although developing countries typically have a larger SE, developed countries generally have comparatively lower shadow economies worldwide. Furthermore, the size of the SE varies between countries around the world due to their diverse economic, social, and institutional characteristics (Schneider and Buehn, 2007; Alm and Embaye, 2013; Kansara et al., 2021).

An additional dimension of the SE is its potential to engender substantial economic and fiscal challenges for nations. The existing literature identifies several adverse consequences associated with the SE. Notably, it diminishes economic growth (Loayza, 1996; Schneider and Hametner, 2014; Borlea et al., 2017; Baklouti and Boujelbene, 2020; Nguyen and Luong, 2020; Camara, 2022) and exacerbates income inequality (Esaku, 2021b; Kum, 2024). Moreover, the SE negatively affects foreign direct investment (FDI) inflows (Yusuf and Nguyen, 2023; Martakusuma and Widodo, 2024), contributes to rising inflation (Mazhar and Méon, 2017), reduces tax revenues (Kodila-Tedika and Mutascu, 2014; Boitano and Abanto, 2019), and precipitates public debt (Owusu-Nantwi and Owusu-Nantwi, 2023) as well as lending rates (Patrick and Akanbi, 2017).

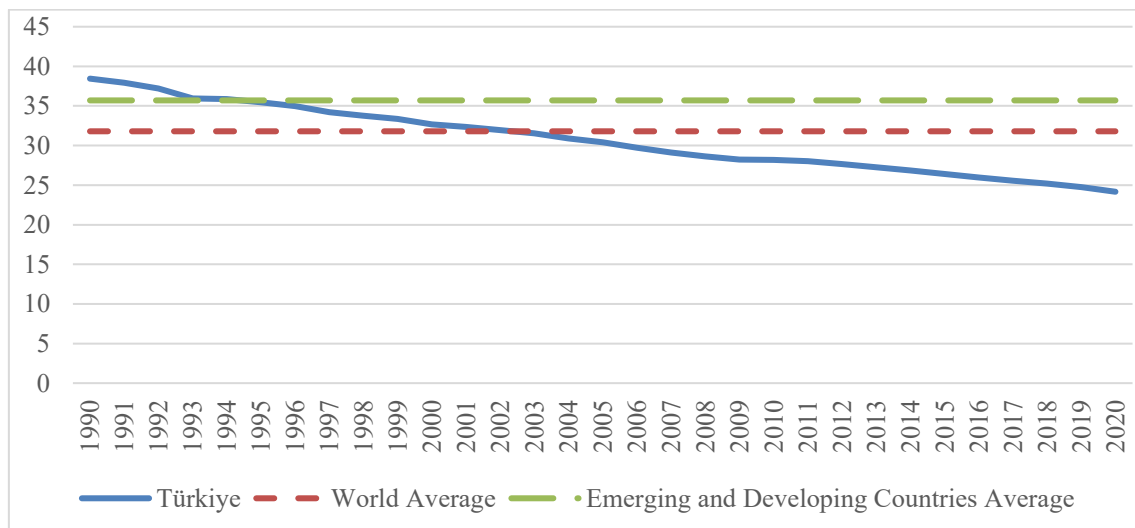


Figure 1. Size of the SE
Source: Elgin et al. (2021a)

This study investigates the effect of innovation, government quality, government size, and inflation on the shadow economy (SE) in Türkiye. Türkiye presents a compelling case due to the substantial size of its SE relative to OECD and European countries, as documented by empirical estimations in the existing literature (Schneider, 2013; Schneider et al., 2015; Medina and Schneider, 2018; Asllani et al., 2024). At the same time, as shown in Figure 1, although the size of the SE in Türkiye was above both the world average and that of EMDEs for a long period, it has exhibited a declining trend over time. In particular, after 1993 and 2003, the size of the SE in Türkiye fell below the corresponding world and EMDE averages, which makes Türkiye an informative case for further analysis. Moreover, the adverse effects of the SE on Türkiye's formal economic sector are well documented in the literature (Atesagaoglu et al., 2017; Uslu, 2021). Overall, the SE in Türkiye negatively affects public finances by reducing tax revenues (Erkus and Karagoz, 2009; Yildiran, 2023) and widening the budget deficit, while simultaneously increasing public borrowing (Yereli et al., 2007), interest payments, and weakening social security contribution revenues (Kaleli and Karaca, 2019). In addition, four action plans targeting the SE have been implemented in Türkiye to date. Overall, these developments reflect Türkiye's efforts to combat the SE (Erdinc, 2016; Celik et al., 2021; TR Ministry of Treasury and Finance, 2022) and underline the importance of examining the effects of different factors on the SE in order to design more effective policy measures.

Drivers of the shadow economy (SE) can differ across countries. In this regard, Asllani et al. (2024) show that the determinants of the SE display substantial heterogeneity across nations. Moreover, Zhanabekov (2022) argues that factors commonly found to be robust at the country-group level (such as tax burden) may lose their explanatory power in individual country settings. Similarly, Schneider (2013) demonstrates that, for OECD countries, institutional quality plays a significant role in explaining the size of the SE, alongside tax and social security contribution burdens. Taken together, these findings suggest that the underlying factors shaping shadow economic activity may differ in the case of Türkiye. At the same time, the existing literature has largely focused on fiscal factors (e.g., tax burden), institutional arrangements, and macroeconomic indicators (Friedman et al., 2000; Schneider and Enste, 2000; Goel and Nelson, 2016; Zhanabekov, 2022; Abu Alfoul et al., 2022; Khan et al., 2023). Building on these insights, this study considers innovation, government size, government quality, and inflation as explanatory variables to examine their potential influence on the SE in Türkiye. To the best of our knowledge, this study is the first to examine the relationship between innovation and the SE specifically in Türkiye, addressing a relatively underexplored aspect of SE research. To our knowledge, only one study investigates the relationship between innovation and SE (Kouakou and Yeo, 2023), and no research examines this specifically for Türkiye.

With regard to innovation and emerging technologies, the ILO Recommendation No. 204 on the Transition from the Informal to the Formal Economy places strong emphasis on the development and diffusion of innovation and technology (including digital technologies and e-government) as key instruments for promoting formalization (Jacobs et al., 2019; Divald, 2021). Additionally, the ILO's Centennial Declaration on the Future of Work recognizes technological innovation as a key driver of transformation in the world of work. Similarly, the 2019 Human Development Report (UNDP, 2019) suggests that e-formalization may promote formalization and enhance productivity (Kring and Leung, 2021). In Türkiye, incentives for research and development provided under the Technology Development Zones Law No. 4691, the Law on the Support of Research and Development Activities No. 5746, and the Corporate Tax Law No. 5520

have led to a rapid increase in both the amount of incentives utilized and R&D expenditures (Sanver and Var, 2023). Rising R&D expenditures, in turn, are widely recognized to have a positive effect on indicators such as trademark registrations and patents (Urasoglu and Celik, 2025). This situation underlines the importance of R&D and innovation for Türkiye. In this framework, the Twelfth Development Plan (2024–2028) sets explicit objectives to further expand R&D incentives and expenditures (TR Presidency of Strategy and Budget, 2023). Moreover, the 2025 Central Government Budget Law Proposal emphasizes the use of technological tools in combating the SE (TR Presidency of Strategy and Budget, 2024a). Likewise, the Medium-Term Program (2025–2027) stresses the adoption of digital monitoring and risk management approaches in tax audits, the use of artificial intelligence in tackling tax evasion, measures targeting informality in digital activities, and a broader utilization of technological capacities to prevent the SE (TR Presidency of Strategy and Budget, 2024b). Taken together, these policy documents further reinforce the increasing emphasis placed on R&D and technological development. From this perspective, whether the recent and ongoing rise in innovation and technological advancement in Türkiye has the potential to promote formalization emerges as an important empirical question.

However, both globally and in Türkiye, increasing innovation and technological development alone may not be sufficient to fully benefit from these processes in terms of formalization. In this respect, countries are required to address formalization policies within a comprehensive and integrated framework (Loayza, 2018; Chacaltana et al., 2018; OECD, 2025). To effectively benefit from the advantages that innovation and technology offer for formalization, the presence of an effective and high-quality government is therefore essential. For instance, technological and innovative changes require governments to design and implement appropriate regulatory frameworks (Alelshaikh and Al Mubarak, 2024), while the need to regulate the expanding digital labor platforms in an effective manner further highlights the importance of governments capable of producing sound and effective policies (OECD, 2023). Similarly, the extent to which e-government—an important outcome of technological innovation—enhances citizens’ trust in public institutions largely depends on the quality of government (Alsaad et al., 2024). In line with the emphasis on institutional quality, the findings of Labhard et al. (2025) indicate that higher-quality institutions facilitate the more rapid diffusion of digital technologies. For this reason, examining the effect of government quality on innovation constitutes an important area of research, particularly in understanding how the potential of innovation to support the transition from informality to formality can be strengthened through effective governance. In conclusion, the extent to which innovation in Türkiye can be supported by government action to facilitate the transition to formalization constitutes an important area of research.

Government size can play both an increasing and a decreasing role with respect to the SE. On the one hand, a larger public sector may indicate that more resources can be allocated to combating SE (Berdiev and Saunoris, 2018; Berdiev et al., 2020). On the other hand, however, a larger government may also be associated with higher levels of corruption, heavier taxation, and increased regulatory burden, all of which can contribute to an expansion of the SE (Macias and Cazzavillan, 2010; Berdiev and Saunoris, 2018; Berdiev et al., 2020; Tran et al., 2024). As a result, the existing literature does not offer a clear consensus regarding the overall effect of government size on the SE. In the case of Türkiye, the combination of a relatively high government size (Bozatli, 2024), the increasing allocation of public resources to the fight against the SE (TR Presidency of Strategy and Budget, 2025), and the recent rise in corruption—as

reflected in declining scores in the Corruption Perceptions Index (Transparency International, 2025)—brings to the forefront the question of whether government size acts to reduce or expand the SE.

In Türkiye, the substantial inflationary pressures observed in recent years (Yuruk and Akgul, 2024) suggest that inflation warrants consideration in the context of shadow economic activities. The literature generally indicates that inflation tends to expand the SE—particularly informal employment—by eroding individuals’ purchasing power and increasing firms’ operating costs (Macias and Cazzavillan, 2010; Abu-Lila et al., 2021). Given that the informal employment rate in Türkiye remains relatively high (ILO, 2025) and that inflation has persisted at elevated levels over an extended period, examining the impact of inflation on the SE becomes empirically relevant, not only in terms of direction but also magnitude. Moreover, existing empirical evidence on the inflation–SE nexus is not fully conclusive across different country contexts (Maddah and Sobhani, 2014; Bansah and Mohsin, 2024), suggesting that country-specific dynamics may condition this relationship. In this respect, the interaction between sustained inflation and SE constitutes a relevant issue for policy analysis in Türkiye, where both phenomena are associated with significant economic and fiscal distortions.

In this study, we examine the effects of innovation, government quality, government size, and inflation on the SE in Türkiye. Using annual time-series data for the period 1990–2020 and applying the Fourier Based DOLS estimation technique, the results suggest that government quality, government size, and innovation are associated with a reduction in the size of the SE. In contrast, the findings indicate that inflation tends to increase shadow economic activity. estimates.

The rest of this paper is structured as follows: Section 2 discusses the definition of SE. Section 3 provides a literature review and presents our hypotheses. The dataset and model are presented in Section 4. Methodology and findings are presented in Section 5. Section 6 provides a discussion based on the existing literature. Finally, Section 7 offers concluding remarks and policy implications.

2. Definition and Measurement of SE

The SE has been the subject of definitional efforts since the 1970s, a period that saw burgeoning literature on shadow activities, as expressed by Dell’Anno (2022). However, many researchers (Schneider, 2013; Schneider and Enste, 2013; Boitano and Abanto, 2019; Yang and Yang, 2024) stress that it is impossible to reach a uniform or agreed-upon definition of the SE. Additionally, the literature utilizes a diverse array of terms to describe the SE, including “hidden”, “informal”, “underground”, “irregular”, “gray”, and “black” economy, which illustrate the definitional challenges (Medina and Schneider, 2018; Zhanabekov, 2022). According to Medina and Schneider (2018), synonyms for “SE” all denote various forms of SE activity. Dell’Anno (2022) points out that the various synonymous terms for “SE” arise from the differing research goals of scientists across various disciplines. Boitano and Abanto (2019) go a step further, emphasizing that the aim of the analysis determines how the SE is defined. In this regard, according to Medina and Schneider's (2018, p. 4) widely accepted definition of the SE: “The shadow economy includes all economic activities which are hidden from official authorities for monetary, regulatory, and institutional reasons.” The authors state that this definition excludes criminal or illegal activities. Because this definition aligns with the goal of our study, we adopt

the definition by Medina and Schneider (2018) to include legal SE activities while excluding illegal ones.

Due to its hidden nature, accurately measuring the precise size of the SE is inherently challenging (Schneider and Williams, 2013; Schneider and Buehn, 2018; Kelmanson et al., 2019). Consequently, various methods have been developed to estimate its size and dynamics. These methods are generally categorized into three groups: direct, indirect, and model-based approaches. Direct methods rely on microeconomic data such as government surveys and tax audits, but may suffer from biased or untruthful responses (Schneider and Buehn, 2018). Indirect methods use macroeconomic indicators and are classified into discrepancy, monetary, and physical input methods (Macias and Cazzavillan, 2010). Discrepancy methods focus on differences between income and expenditure GDP measures and labor force statistics. Monetary methods assume that SE transactions are conducted in cash, linking currency demand to shadow activity. Physical input methods use deviations between GDP growth and electricity consumption as proxies (Macias and Cazzavillan, 2010; Schneider and Buehn, 2018; Kelmanson et al., 2019). Model-based methods mainly include the Multiple Indicators Multiple Causes (MIMIC) model and the Dynamic General Equilibrium (DGE) model (Zhanabekov, 2022). The MIMIC model estimates the SE as a latent variable driven by observable causes and indicators (Schneider and Williams, 2013), with the DYMIMIC variant incorporating dynamics over time (Dybka et al., 2019). The DGE model analyzes household labor allocation between formal and informal sectors to maximize utility, capturing temporal changes (Elgin et al., 2021a, 2021b; Bohórquez, 2023). In summary, although multiple methods exist to estimate the SE, none provide an exact measure due to inherent limitations (Schneider and Williams, 2013).

3. Literature Review

In addition to reviewing literature, this section examines how government size, innovation, quality, and inflation affect the SE. Furthermore, we also postulate the testable hypotheses.

3.1. Theoretical Perspectives on SE

Literature broadly distinguishes between two main approaches to explaining the SE. The first approach views the SE primarily as a consequence of poor governance. In this sense, the SE emerges in overregulated and weakly governed economic environments. Within this framework, firms and workers tend to operate informally when the perceived benefits of informality, most notably the avoidance of excessive regulation, outweigh the costs associated with limited access to public services available to formal firms and employees. From this perspective, the key policy response involves establishing a well-functioning, high-quality public sector and improving the regulatory environment (Loayza, 2018). Indeed, improvements in government quality raise the costs of engaging in shadow activities relative to formal economic participation (Autio and Fu, 2015). This occurs through several channels, including the reduction of business costs, the protection of intellectual property rights (Ameer et al., 2025), and the mitigation of regulatory burdens alongside the promotion of economic freedom (Berdiev et al., 2018).

The second approach interprets the SE as a manifestation of underdevelopment. Within this framework, the prevalence of the SE is largely attributed to the low productivity of both firms and the labor force. Low productivity may stem from limited human and physical capital

accumulation, as well as from certain sociodemographic characteristics, such as a high share of rural or youth populations (Loayza, 2018). More recent contributions to the literature emphasize that innovation capacity and technology adoption constitute important determinants of productivity performance (Taymaz, 2023). Evidence from OECD (2025b) and Amin and Okou (2020) indicates that productivity levels in informal firms are generally low and that competition from informal firms can weaken the competitiveness and innovation incentives of formal firms. At the same time, a growing body of research suggests that, as a result of technological innovation, digital technologies may enhance labor productivity within informal firms by improving efficiency and production processes (Danquah and Owusu, 2021; Sodokin et al., 2023; Erumban, 2024).

Lastly, while both approaches offer valid explanations, the SE should be understood as a complex and multifaceted phenomenon. Its prevalence cannot be attributed to a single cause, and the relative importance of poor governance and low productivity in explaining the SE varies across countries (Loayza, 2018).

3.2. Empirical Literature and Hypotheses

3.2.1. Government Quality and SE

There is a widespread consensus in the literature that a decrease in SE is associated with improved institutional quality. In literature, studies (Dreher et al., 2009; Schneider, 2010; Barra and Papaccio, 2024; Tran et al., 2024) that use different proxies for institutional quality (or quality of government institutions) (such as rule of law, regulatory quality, government effectiveness) show that institutional quality reduces the SE. Indeed, various studies show that improvement in institutional quality plays an important role in decreasing the SE (Loayza, 1996; Rei and Bhattacharya, 2008; Torgler and Schneider, 2009; Dreher et al., 2009; Schneider, 2010; Ouédraogo, 2017; Devine, 2021; Abu Alfoul et al., 2022; Barra and Papaccio, 2024; Tran et al., 2024; Ameer et al., 2025).

The literature generally agrees that institutional quality has a decreasing effect on the SE, as we have discussed. According to Autio and Fu (2015), this consensus arises from the understanding that a higher quality of institutions increases the costs of engaging in shadow activities compared to formal economic activities. For instance, Esaku (2021a) highlights that the ability of corrupt officials to demand bribes is curtailed when institutional quality improves. Hassan and Schneider (2016) contend that the freedom to start new businesses, a strong rule of law, efficient regulations, secure property rights, and enforceable contracts all serve to heighten the benefits of remaining within the official economy, while simultaneously increasing the costs associated with shadow activities. Conversely, regulatory burdens, corruption, and bureaucratic obstacles compel economic agents to remain within the SE.

Torgler and Schneider (2009) emphasize that higher institutional quality increases economic actors' identification with government institutions by enabling them to participate in the political process and articulate their views, while also reducing their tendency to engage in the SE. Zhanabekov (2022) posits that strong institutions foster greater public confidence in government efficacy, encouraging citizens to contribute to general well-being by making social contributions and paying taxes. Ameer et al. (2025) argue that enhanced institutional quality

diminishes business costs and protects intellectual property rights, thereby bolstering investor confidence to establish commercial ventures and promoting the official economy.

Additionally, some studies elucidate alternative channels through which institutional quality affects the SE. For example, Berdiev et al. (2018) assert that well-qualified institutions, characterized by limited regulation and governance, enhance property protection and support economic freedom, which, in turn, encourages economic agents to exit shadow activities. Loayza et al. (2005) suggest that the enhancing effects of heavy regulatory burdens on the SE are lessened by improved institutional structure. According to Farzanegan and Buehn (2013), education has a moderating influence on the SE, but only when there are high-quality institutions at present. Furthermore, Berdiev et al. (2020) argue that higher government quality diminishes the positive relationship between poverty and the SE.

Considering the discussions above, we propose the following hypothesis:

Hypothesis 1: Higher government quality reduces the SE.

3.2.2. Innovation and SE

Because the existing literature has predominantly focused on factors such as social security contributions, tax burden, GDP growth, inflation, and unemployment, studies directly examining the relationship between innovation and the SE remain relatively limited. One of the few comprehensive contributions in this area is Kouakou and Yeo (2023), who analyze the effect of innovation, proxied by R&D expenditures and an innovation output index, and find that innovation has a negative effect on the SE across 138 countries over the period 2007–2018. With regard to the transmission mechanisms, Kouakou and Yeo (2023) identify three main channels through which innovation influences the SE: domestic credit mobilization, e-government development, and overall economic development. From this perspective, improvements in economic development, more effective domestic credit allocation, and the strategic use of e-government services are argued to contribute to a reduction in the size of the SE.

In line with these findings, several studies emphasize that technology use and adoption among informal firms remain limited (Taymaz, 2023; OECD, 2025). As a result, informal firms tend to exhibit low productivity, and their competition with formal firms may weaken innovation incentives in the formal sector, as documented by Amin and Okou (2020) for a sample of 110 countries. At the same time, other studies highlight the potential productivity-enhancing role of digital technologies developed through technological innovation. In particular, Erumban (2024) and Sodokin et al. (2023) show that information and communication technologies and internet usage can increase productivity in informal firms. However, these studies also point to important challenges. For instance, Sodokin et al. (2023) find that the expansion of online business operations and digital adoption may reduce employment, underscoring the critical role of governance in shaping whether the outcomes of technological progress translate into favorable effects on the SE.

E-government is relevant insofar as it reflects how digital technological progress, together with innovation, may influence the SE. With advances in digital technologies, e-government initiatives have increasingly been used as tools to promote formalization in areas such as labor registration, tax administration, inspections, and cashless payments (Chacaltana et al., 2018; Bhattarai, 2018; Divald, 2021). The literature generally suggests that e-government is associated

with changes in the size of the SE, although the direction and magnitude of these effects vary (Chacaltana et al., 2018; Elbahnasawy, 2021; Doan et al., 2025). Empirical findings further indicate that these effects are heterogeneous across countries and depend on national conditions (Chacaltana et al., 2018; Doan et al., 2025). In particular, unequal access to digital technologies may limit the effectiveness of e-government and, in some cases, even contribute to higher SE (Chacaltana et al., 2018, 2024).

In addition, innovation may influence the SE through its effects on informal employment, especially in economies where informal employment constitutes a substantial share of total employment. The literature widely acknowledges that informal workers are predominantly low-skilled (OECD, 2024). Moreover, innovation tends to have a weaker employment-creating effect for low-skilled workers compared to high-skilled workers, and in some cases may even reduce employment opportunities for the low-skilled (de Elejalde et al., 2015; Diaz et al., 2020; Liu et al., 2024). Recent evidence further suggests that the impact of technological innovation on informal employment is heterogeneous across contexts. In line with this view, Zhang et al. (2025) find that the increasing use of robots in China is negatively associated with informal employment among college graduates, indicating potential formalization effects for skilled workers. In contrast, Linghu (2025) shows that robot adoption increases the likelihood of informal employment, highlighting that automation may also displace vulnerable workers toward informality.

Consequently, by disproportionately affecting low-skilled employment, innovation may contribute to an expansion of informal employment—and hence the SE—in contexts where informality in the labor market is widespread.

Considering these theoretical arguments and the relatively high but declining share of informal employment in Türkiye compared to global averages (ILO, 2025), innovation-driven productivity and formalization effects are expected to dominate. Accordingly, we propose the following hypothesis:

Hypothesis 2: Higher innovation is associated with a reduction in the size of the SE.

3.2.3. Government Size and SE

Regarding the effect of government size on the SE, there is no agreement in the literature. According to some studies, the size of the government has a positive effect on the SE, while others report that government size negatively affects the SE. For instance, utilizing government expenditure (a proxy for government size), a number of studies (Macias and Cazzavillan, 2010; Schneider et al., 2010a; Buehn and Schneider, 2012; Xu et al., 2018; Berdiev and Saunoris, 2018; Berdiev et al., 2020; Esaku, 2021a, 2021c; Zhanabekov, 2022; Vo et al., 2023; Tran et al., 2024) find that government size positively influences the SE. In contrast, Goel and Nelson (2016), and Schneider et al. (2010a), Huynh and Nguyen (2020), Khan et al. (2023), and Siddik et al. (2022) conclude that government size has a negative effect on the SE. In addition, Rei and Bhattacharya (2008) show that in developing countries, there is an u-shaped relationship between the SE and government size.

Additionally, several studies emphasize that the regulatory burden functions as a contaminant to the size of government. In this context, Macias and Cazzavillan (2010) assert that the size of government serves as an indicator of bureaucracy and a heavy regulatory burden, both

of which play significant roles in the enlargement of the SE. Furthermore, Hassan and Schneider (2016) demonstrate that the regulatory burden (as proxy for government size) has a positive effect on the SE, as stringent regulations foster bureaucracy and constrain business freedom and entrepreneurial entry.

Regarding the channels through which government size affects the SE, Berdiev et al. (2020), and Berdiev and Saunoris (2018) emphasize that government size may influence the SE both positively and negatively. In this context, the authors argue that, through onerous taxation and the crowding out of market activity, large governments may increase the SE by driving entrepreneurs to operate in the underground economy. Conversely, large governments may allocate greater resources to combat the SE, and hence, the SE may be affected negatively.

Additionally, stressing the increasing effects of government size on the SE, Dell'Anno et al. (2018) argue that large governments may cause distortions in resource allocation and potentially lead to higher corruption. Tran et al. (2024), and Vo et al. (2023) refer to the legalism hypothesis in explaining the positive effect of government size on the SE. According to this hypothesis, large government sizes are associated with decreasing effectiveness of government expenditures, heavy regulations, high red tape, and consequently the crowding out of productive investments. As mentioned above, Hassan and Schneider (2016), and Macias and Cazzavillan (2010) emphasize that large government size is associated with heavy regulations, which increases the SE.

Explaining the channels through which government size affects the SE negatively, Goel and Nelson (2016) emphasize that a large government size causes strengthened checks and balances, which restrict the SE. Siddik et al. (2022) argue that government expenditure increases wages in the formal sector, which restricts the SE. Lastly, Huynh and Nguyen (2020) argue that a large government sector may reallocate resources to the official economy, increase GDP growth, enhance the quality of public services, and hence limit the size of the SE.

Based on the arguments above and given that significantly large governments in Türkiye (Bozatlı, 2024) generally aim to combat the SE, we propose the following hypothesis:

Hypothesis 3: Larger government size reduces the SE.

3.2.4. Inflation and SE

The effect of inflation on the SE has been the subject of numerous research, consistently indicating that inflation tends to expand the size of this informal sector. In this regard, research by Abu-Lila et al. (2021) and Macias and Cazzavillan (2010) demonstrates that inflation positively affects the SE in Jordan, Türkiye, and Mexico, respectively. In a similar vein, for a diverse range of country groups, Schneider et al. (2010a), Buehn and Schneider (2012), Maddah and Sobhani (2014), Goel and Nelson (2016), and Baklouti and Boujelbene (2019) find that inflation positively affects the SE in developing countries.

The channels through which inflation affects the SE rely on the argument that inflation reduces the purchasing power of people and production costs of firms, thereby prompting agents to operate in the SE. Maddah and Sobhani (2014) argue that inflation decreases the purchasing power of individuals, while Goel and Nelson (2016) contend that inflation increases the production and operating costs of firms and raises the discount rates. Another argument regarding

the relationship between inflation and the SE focuses on the tax burden. For instance, according to Tran et al. (2024), inflation prompts individuals to get involved in SE activities to evade taxes. By a similar argument, Fishburn (1981) stresses that during periods of high inflation, individuals' incomes must be indexed to keep real income constant. However, Alm and Embaye (2013) and Crane and Nourzad (1986) argue that even if cost-of-living adjustments maintain real income at a stable level, inflation may push individuals into higher tax brackets, resulting in higher income taxes. These arguments indicate that inflation may increase the SE by raising the taxes payable. Lastly, Bansah and Mohsin (2024) argue that inflation can decrease the SE as long as access to credit is high enough. The rationale behind this argument is that firms in the formal sector can fully access credit and avoid the inflation tax, while firms in the SE pay the inflation tax because of the cash-based nature of the SE.

Considering the discussions above, we propose the following hypothesis:

Hypothesis 4: Higher inflation increases the SE.

4. Data and Model

Using accessible time series data spanning the years 1990–2020, this study aims to examine the effects of inflation, government size, quality, and innovation on Türkiye's SE. The variables utilized in this study are presented in Table 1, together with their sources and descriptions.

Table 1. Descriptions and Sources of Variables

Variable	Description	Sources
Dependent variable		
Shadow economy (<i>se</i>)	Size of shadow economy (% of GDP): Estimation based on DGE Model	(Elgin et al., 2021a)
Independent variables		
Innovation (<i>inv</i>)	Gross domestic R&D expenditure (% of GDP).	OECD Database
Government quality (<i>gq</i>)	ICG indicator of quality of government: Ranges from 0 to 1, where lower values reflect lower quality of government, <i>and vice versa</i> .	Knoema Database
Government size (<i>gs</i>)	Government expenditure (% of GDP).	IMF DataMapper
Inflation (<i>inf</i>)	The inflation rate, consumer prices (%).	WDI

The data on the shadow economy (*se*) (dependent variable) are sourced from (Elgin et al., 2021a), which provides the longest and most comprehensive dataset for Türkiye. The authors assess the SE utilizing the DGE model across various countries, including Türkiye, from 1990 to 2020. Consequently, our analysis is limited to the time frame for which data on the SE are accessible. Moreover, the DGE model has been employed in numerous studies (Ahmad and Hussain, 2023; Pham et al., 2023; Capasso et al., 2024; Thanh et al., 2024) to explore the SE. Therefore, we adopt DGE-based data on the SE for the present study.

In this study, we have four independent variables: innovation (*inv*), government quality (*gq*), government size (*gs*), and inflation (*inf*). Following the extant literature (Kouakou and Yeo, 2023), we use R&D expenditures (% of GDP) as a proxy for “innovation”. The data for R&D expenditure comes from the OECD Database. For the government quality variable, we utilize the rescaled International Country Risk Guide (ICRG) indicator of “quality of government” produced

by the PRS Group (2025). This ICRG indicator represents the average values of variables such as bureaucracy quality, corruption, and law and order, on a scale from 0 to 1, where lower values indicate lower quality of government and *vice versa* (Dahlberg et al., 2024). The ICRG indicator is commonly referenced in the literature for researching government quality (Dell’Anno, 2020; Peveri, 2022; Ferreira, 2024). In line with previous research (Dell’Anno et al., 2018; Zhanabekov, 2022), we use government expenditure as a percentage of GDP as a proxy for “government size,” with the data sourced from the IMF DataMapper. For the “inflation” variable, we use the consumer price index as a proxy, as utilized in the relevant literature (Alm and Embaye, 2013; Baklouti and Boujelbene, 2019; Bansah and Mohsin, 2024), and we collect data from the World Development Indicators (WDI). All the data is used in logarithmic form. The following model was used in light of literature review and the research goal:

$$\ln se_t = \beta_0 + \beta_1 \ln inv_t + \beta_2 \ln gq_t + \beta_3 \ln gs_t + \beta_4 \ln inf_t + \varepsilon_t \quad (1)$$

where ε_t is the error term and $\beta_0, \beta_1, \beta_2, \beta_3, \beta_4$ are coefficients of the constant, innovation, government quality, government size, and inflation, respectively. We expect innovation, government quality, and government size to impact the SE and decrease it significantly. However, we expect inflation to have an enhancing effect on the SE.

5. Methodology and Empirical Results

5.1. Methodology

Time series may be exposed to various shocks over time, which can lead to structural changes in their underlying behavior. A structural break is defined as a change in the parameters of the underlying model resulting from an external shock (Kalsie and Arora, 2019). Structural changes, or breaks, are commonly observed in models describing the evolution of key economic and financial time series, including output growth, inflation, exchange rates, interest rates, and stock returns. Such changes may reflect legislative, institutional, or technological developments, shifts in economic policy, or the impact of major macroeconomic shocks (Pesaran et al., 2006). Unexpected and abrupt changes may alter the relationships among variables, posing a common challenge in empirical analysis. When structural changes are not taken into account, empirical models may become misspecified, leading to biased parameter estimates, large post-break forecast errors, and potentially misleading policy implications. Moreover, ignoring structural changes may result in inappropriate testing of economic theories and unreliable empirical conclusions (Castle and Hendry, 2019).

Structural breaks can take the form of sharp (abrupt) changes or smooth, gradual transitions. Fourier approximation performs particularly well when structural breaks are smooth (Enders and Holt, 2012). Incorporating smooth structural changes through Fourier approximation allows for more reliable and sensitive empirical results (Aydin and Bozatli, 2023). In addition, this approach offers several practical advantages, including the avoidance of issues related to the selection of the timing, number, and functional form of structural breaks (Emirmahmutoglu et al., 2021). For these reasons, we adopt Fourier-based tests in this study.

Structural changes in economic variables often evolve gradually rather than occurring instantaneously, reflecting the heterogeneous behavior of economic agents. Accordingly, empirical approaches that allow for smooth parameter changes have been widely used to model such dynamics. In this context, unit root tests based on Gallant’s (1981) flexible Fourier form and

the smooth transition (ST) approach proposed by Leybourne et al. (1998) have been developed to account for smooth structural changes in time series. In this regard, Becker et al. (2006) extended the test proposed by Kwiatkowski et al. (1992) by incorporating Gallant's (1981) Fourier functions and developed a stationarity test that does not require prior information on the timing, number, or form of structural breaks, while remaining effective under smooth change processes (Emirmahmutoglu et al., 2021; Bozatli et al., 2024).

The data-generating process underlying the Fourier KPSS (FKPSS) test is specified as follows:

$$\begin{aligned} y_t &= X_t' \beta + Z_t' \gamma + r_t + \varepsilon_t \\ r_t &= r_{t-1} + u_t \end{aligned} \tag{2}$$

In Eq. (2), ε_t shows the error term, and $Z_t = [\sin(2\pi kt/T), \cos(2\pi kt/T)]'$ used to capture breaks, where T and k denotes sample size and frequency parameter, respectively. Accordingly, the regression models used for the FKPSS test under stationarity and trend stationarity are given by:

$$y_t = \alpha_1 + \gamma_1 \sin\left(\frac{2\pi kt}{T}\right) + \gamma_2 \cos\left(\frac{2\pi kt}{T}\right) + u_1 \tag{3}$$

$$y_t = \alpha_1 + \delta_t + \gamma_1 \sin\left(\frac{2\pi kt}{T}\right) + \gamma_2 \cos\left(\frac{2\pi kt}{T}\right) + u_1 \tag{4}$$

To test stationarity, where the null hypothesis implies stationarity and the alternative hypothesis indicates the presence of a unit root, the test statistics are defined as:

$$t_\mu(k) \text{ or } t_T(k) = \frac{1}{T^2} \frac{\sum_{t=1}^T \tilde{S}_t(k)^2}{\hat{\sigma}^2} \tag{5}$$

In Eq. (5), $\tilde{S}_t(k) = \sum_{j=1}^t \hat{\varepsilon}_j$, where $\hat{\varepsilon}$ denotes the OLS residuals obtained from Equation (3) or Eq (4).

Once the stationarity of the series is determined using unit root tests, the existence of a long-run relationship is examined through cointegration tests. Nevertheless, traditional cointegration methods may produce biased results since structural breaks are ignored in the estimation process (Kızılkaya et al., 2024). Accordingly, Tsong et al. (2016) developed a new cointegration test, namely the Fourier Shin Cointegration Test (FSHIN), by incorporating Fourier functions into the cointegration test proposed by Shin (1994) in order to account for smooth structural breaks. The test can be expressed as follows:

$$y_t = e_t + x_t' \beta + \eta_t \tag{6}$$

In Eq. (6), $\eta_t = \gamma_t + v_{1t}$, $\gamma_t = \gamma_{t-1} + u_t$, $x_t = x_{t-1} + v_{2t}$ where v_t is an independently and identically distributed process with zero mean and variance σ_u^2 , and γ_t follows a random walk process with zero mean.

The null hypothesis of cointegration is tested against the alternative hypothesis of no cointegration, and the corresponding test statistic is defined as follows:

$$CI_m^f = T^{-2} \hat{\omega}_1^{-2} \sum_{t=1}^T S_t^2 \quad S^t = \sum_{t=1}^T \hat{v}_{1t} \tag{7}$$

Finally, Tsong et al. (2016) examine the significance of the Fourier terms using an F-test. If these Fourier terms are found to be statistically significant, the FSHIN test is considered appropriate for cointegration analysis. Moreover, Tsong et al. (2016) recommend using the DOLS method to estimate the long-run relationship.

5.2. Empirical Results

To illustrate the variable structures, we present the descriptive statistics for the variables in Table 2 before the empirical analysis. According to the results, the mean value of the SE is 3.416, which is the highest value among the variables. On the other hand, the mean values of government size and inflation (3.409 and 3.096, respectively) are higher than the mean value of innovation. Additionally, having the highest standard deviation value (1.029) among the variables, inflation shows significant variation. With the second-highest standard deviation (0.507), innovation also shows significant variation. Other variables (SE, government quality, and government size) have relatively lower standard deviations.

Table 2. Summary of the Descriptive Statistics of Variables

	lnse	lninv	lngq	lngs	lninf
Mean	3.416	-0.541	-0.644	3.409	3.096
Median	3.414	-0.592	-0.656	3.509	2.719
Maximum	3.649	0.312	-0.351	3.785	4.656
Minimum	3.184	-1.445	-0.944	2.643	1.832
Std. Dev.	0.136	0.507	0.146	0.273	1.029

The results of the correlation analysis and VIF test are shown in Tables 3 and 4, respectively. The correlation analysis reveals a significant correlation between SE (dependent variable) and independent variables (innovation, government quality, government size, and inflation). Furthermore, the VIF test indicates the model has no problem of multicollinearity.

Table 3. Correlation Analysis

	lnse	lninv	lngq	lngs	lninf
lnse	1.000000				
lninv	-0.973581	1.000000			
lngq	0.392455	-0.459872	1.000000		
lngs	-0.696573	0.674894	-0.198474	1.000000	
lninf	0.827397	-0.796521	0.308088	-0.588291	1.000000

Table 4. VIF Results

	lninv	lngq	lngs	lninf
VIF	3.97	1.32	1.91	2.79

To choose the appropriate estimating method, it is crucial to ascertain the variables' integration order. Thus, we used a stationarity test, which considers structural breaks. The results of the stationarity tests are shown in Table 5. The results indicate that all the variables have a unit root at the level and become stationary after being first differenced, which means that all the variables are stationary at level I(1).

Table 5. FKPSS Stationarity Test Results

Variables	I(0)	1%	5%	10%	I(1)	1%	5%	10%
lnse	1.0969 (1)*	0.269	0.172	0.131	0.079 (4)	0.722	0.459	0.347
lninv	0.986 (1)*	0.269	0.172	0.131	0.061 (3)	0.718	0.448	0.339
lngq	0.407 (2)***	0.667	0.415	0.315	0.195 (2)	0.667	0.415	0.315
lngs	0.907 (1)*	0.269	0.172	0.131	0.102 (1)	0.269	0.172	0.131
lninf	0.439 (1)*	0.269	0.172	0.131	0.054 (1)	0.269	0.172	0.131

Note: * and *** indicate rejection of null hypothesis which indicates stationarity at 1% and %10 significance level, respectively. Values in parentheses denote optimal frequency numbers.

We performed FSHIN cointegration test to examine the long-term relationship between the variables of the study after determining that all of the variables are stationary at the I(1) level. According to FSHIN test results in Table 6, the F-test is significant, and SE moves together with the innovation, government quality, government size, and inflation in the long run. This implies cointegration between the SE and other variables under structural breaks.

Table 6. Fourier Shin (FSHIN) Cointegration Test Results

Test	Value	k	1%	5%	10%
Fourier Shin	0.161*	3	0.192	0.111	0.086
F-Test	7.056*	-	5.774	4.066	3.352

Note: * indicates significance at %1 level.

After ascertaining the cointegration of the variables, we employed the Fourier-based DOLS method to analyze the effects of independent variables on the SE, which is the dependent variable. The findings, which are displayed in Table 7, demonstrate that innovation, government quality, and government size have a negative effect on the SE. In contrast, inflation positively and significantly affects the SE. Accordingly, increases in innovation, government quality, and government size decrease the SE, while the SE increases as inflation rises.

Table 7. Fourier Based DOLS Long-Run Estimation Results

Independent Variables	Coefficient	Prob.
lninv	-0.128*	0.0005
lngq	-0.051***	0.0876
lngs	-0.134*	0.0037
lninf	0.107*	0.0001

Note: * and *** indicate 1% and 10 %significance, respectively.

The empirical findings of the study yield a range of conclusions. Consistent with a priori expectations, our results indicate that innovation reduces the SE. This finding implies that, given the increasing levels of innovation in Türkiye, innovation helps to diminish the SE. Additionally, in line with our expectations, government size and government quality are found to mitigate the SE. This suggests that enhanced government quality increases the benefits of remaining in the formal economy, while larger governments might be better able to counteract the SE by utilizing resources to combat it. In this regard, in Türkiye, one of the main aims of the government is to decrease the SE due to its detrimental effects, particularly on tax revenues. Thus, enhancing government size decreases the SE in Türkiye. Lastly, consistent with our expectations, inflation

enhances the SE. Indeed, Türkiye experiences fluctuating and often high inflation rates, which compel individuals and companies to operate in the SE.

6. Discussion

This study empirically examines the effects of innovation, government quality, government size, and inflation on the shadow economy in Türkiye. The results indicate that innovation has a negative effect on the SE, which is consistent with the existing literature (Kouakou and Yeo, 2023). This finding may be explained by several underlying mechanisms that are particularly relevant to the Turkish context. First, productivity gains associated with innovation may increase firm profitability and growth prospects, thereby strengthening incentives to operate within the formal sector. Second, the expansion of e-government applications and digital public services may limit SE by improving monitoring capacity and reducing compliance costs. In Türkiye, innovation and R&D expenditures have increased notably in recent decades, especially following the introduction of R&D tax incentives in the 2000s (Gonen and Kisakurek, 2022; Tas and Erdil, 2023). Moreover, a growing body of evidence shows that innovation positively affects productivity and, in turn, economic growth in Türkiye (Fazlioglu et al., 2019; Tuncel and Oktay, 2022). In line with these developments, Türkiye's policy framework places strong emphasis on productivity-led growth through price and financial stability, high value-added production, and green and digital transformation (TR Presidency of Strategy and Budget, 2024c). Such a policy orientation may indirectly contribute to reducing the SE by encouraging formal economic activity. In addition, according to the UN E-Government Survey 2024 (UN, 2024), Türkiye ranks 27th globally and is classified in the very high e-government development index group. In practice, e-government initiatives in taxation—such as e-invoicing, electronic tax filing, and automated tax administration and audit systems—are widely implemented (Akdogan and Yavuz, 2022), indicating an active use of digital tools in tax administration. These developments may further support efforts to reduce the SE in Türkiye. Nevertheless, as suggested in the literature (Chacaltana et al., 2018; Sodokin et al., 2023; Naik and Nandakumar, 2025), innovation-oriented policies alone may not be sufficient. For productivity gains and e-government practices to effectively curb the SE, innovation and digital technologies need to be broadly accessible to firms and individuals, and government capacity must be strong enough to implement and sustain innovation-based policies.

Our econometric results indicate that government quality has a negative effect on the size of the SE, which is consistent with a broad strand of the literature (Dreher et al., 2009; Torgler and Schneider, 2009; Schneider, 2010; Barra and Papaccio, 2024; Ameer et al., 2025). Government quality, as reflected in indicators such as the rule of law, bureaucratic quality, and control of corruption, shapes the institutional environment in which economic agents operate (PRS Group, 2025). Improvements in these dimensions tend to increase the relative costs of informal activities by strengthening enforcement, reducing regulatory uncertainty, and enhancing trust in public institutions (Autio and Fu, 2015). In the case of Türkiye, government quality indicators, including sub-components related to the rule of law, bureaucratic quality, and corruption, have shown a declining trend in recent years, although they remain above the global average (PRS Group, 2025). Earlier improvements in government quality, particularly in the early 2000s, may have contributed to reducing the SE through better regulatory frameworks, lower corruption, and more effective public administration. These findings suggest that government

quality plays a crucial role not only as a direct determinant of SE but also as a complementary factor that enhances the effectiveness of other policy instruments. As emphasized in the literature, combating the SE requires a comprehensive approach in which innovation and digitalization policies are supported by adequate institutional capacity (Loayza, 2018; Chacaltana et al., 2018; OECD, 2025). In this regard, the effective use of digital and innovative tools—particularly in areas such as tax compliance and enforcement—depends on coordination among public institutions and the quality of governance structures. In Türkiye, policy documents emphasize the importance of institutional coordination, data integration, and regulatory improvements, including initiatives such as the Action Plans for Combating the Informal Economy aimed at reducing SE (TR Presidency of Strategy and Budget, 2024b). Nevertheless, explicit links between specific government quality indicators and the size of the SE are often not clearly articulated in these documents. Ongoing efforts to strengthen the legal framework and enhance inter-institutional coordination (TR Ministry of Treasury and Finance, 2022) suggest that, in the context of combating SE, government quality in Türkiye has not yet reached full institutional maturity, while also indicating substantial room for further improvement. From this perspective, strengthening government quality may serve as a key enabling factor that amplifies the impact of innovation-based policies in reducing the SE.

Regarding government size, our results indicate a negative relationship with the size of the SE, which is consistent with the existing literature (Huynh and Nguyen, 2020; Siddik et al., 2022; Khan et al., 2023). A larger government may be associated with greater capacity to allocate resources to monitoring, enforcement, and institutional mechanisms aimed at reducing SE. In Türkiye, substantial projects and legal measures have been implemented in recent years to combat the SE (Celik et al., 2021). In parallel, government expenditures have increased steadily, suggesting that a share of public resources is directed toward addressing the SE (TR Presidency of Strategy and Budget, 2024c, 2025). This may partly explain the observed negative association between government size and the SE. At the same time, the literature also points out that a larger government size can be associated with higher taxation, heavier regulatory burdens, and increased corruption, which may encourage SE (Macias and Cazzavillan, 2010; Berdiev and Saunoris, 2018; Berdiev et al., 2020; Tran et al., 2024). From this perspective, the negative effect found in this study may suggest that public expenditures aimed at combating the SE can help offset some of the adverse effects of regulatory complexity and tax pressure. More broadly, these results indicate that the impact of government size on SE is likely to be shaped by the quality of governance and institutional capacity, pointing to the relevance of a more integrated policy framework. Hence, a larger government size in Türkiye contributes to restrain on the SE.

Lastly, our results indicate that inflation has a positive effect on the size of the SE, which is in line with previous studies (Macias and Cazzavillan, 2010; Buehn and Schneider, 2012; Alm and Embaye, 2013; Maddah and Sobhani, 2014; Goel and Nelson, 2016; Baklouti and Boujelbene, 2019). In the case of Türkiye, inflationary pressures have been substantial in recent years (Yuruk and Akgul, 2024). The inflation rate in Türkiye has remained well above the OECD average, and Türkiye has recently recorded the highest consumer price inflation among OECD countries (OECD, 2026).

High inflation may encourage SE by eroding real incomes and increasing production and operating costs, thereby pushing both individuals and firms to seek alternative ways to maintain their purchasing power and profitability. In this context, persistent inflation in Türkiye may have contributed to an expansion of the SE by weakening compliance incentives and increasing

economic vulnerability. These findings suggest that controlling inflation is not only important for macroeconomic stability but may also play a supportive role in reducing SE and strengthening the resilience of the Turkish economy.

Taken together, these findings suggest that addressing the SE requires a policy synthesis in which innovation, government quality, government size, and macroeconomic stability are considered jointly rather than in isolation.

7. Conclusion and Policy Implications

The shadow economy continues to attract significant interest from researchers due to its considerable size and detrimental effects on economies. Given the ineffectiveness of conventional policies in addressing the shadow economy (SE) (Nguimkeu, 2022), it becomes crucial to focus on the factors that influence it (Ott, 2002). In this study, we explore the effects of innovation, government quality, government size, and inflation on the SE in Türkiye, utilizing annual data from 1990 to 2020 along with time series techniques. Employing the Fourier Shin cointegration test, we offer empirical proof of the long-run relationship between the identified independent variables and the SE. We then estimate the long-run coefficients using the Fourier-based DOLS method. Our results reveal that innovation, government quality, and government size negatively affect the SE, while inflation has a positive effect. These findings emphasize the critical roles of innovation, government quality, and government size in mitigating the SE's growth, as well as highlighting the escalating influence of inflation in Türkiye and the urgent need for policies to combat high inflation.

Based on the findings, our study presents several policy implications to combat the shadow economy. To reduce the shadow economy, increasing innovation and R&D expenditure appears to be an important strategy. Given its positive effects on exports, productivity, and economic growth, as well as its mitigating impact on informality, innovation policies should be incentivized in a more comprehensive manner in Türkiye. Such incentives may include tax advantages or programs aimed at improving technological skills and knowledge.

However, existing evidence suggests that the effectiveness of R&D incentives in Türkiye remains limited despite recent regulatory efforts (Tasiyan and Cadırcı, 2024). This indicates the need to evaluate not only the scale but also the efficiency of R&D support mechanisms. Moreover, although public support for innovation in Türkiye is relatively high compared to many countries, instruments such as R&D loans and direct subsidies remain limited (Sanver and Var, 2023). Expanding and diversifying these support mechanisms could strengthen the link between R&D expenditures and innovation outcomes. In addition, fostering an innovation-oriented culture may encourage greater private sector involvement in innovative activities.

At the same time, improvements in innovation and R&D alone may not be sufficient to effectively reduce the SE. As discussed earlier, innovation-driven policies are more likely to be effective when accompanied by broad access to digital technologies and their active use in strengthening government capacity. In this context, innovation and technology policies need to be supported by adequate government quality in order to enhance their impact on formalization and the reduction of the SE.

In addition to its direct effect on reducing the shadow economy, government quality also plays an important complementary role by enhancing the effectiveness of innovation-based

policies. Accordingly, strengthening government quality emerges as a key policy priority for reducing the SE in Türkiye. Although recent trends indicate a decline in several sub-components of government quality, such as bureaucratic quality, control of corruption, and law and order, improvements in these areas remain critical for combating informality.

In particular, legal and administrative reforms aimed at simplifying bureaucratic procedures, reducing corruption, and strengthening enforcement mechanisms may contribute to lowering the SE. International experience suggests that such reforms can be effective when adapted to country-specific conditions. For instance, policies such as incentive-based formalization schemes and simplified administrative procedures have been successfully implemented in various countries (Bhattarai, 2018; Chacaltana et al., 2018; Divald, 2021).

Concrete policy options for Türkiye may include the adoption of one-stop shop models to facilitate firm entry and business registration, as applied in many countries (Kuriyama and Simanjuntak, 2024), as well as the expansion of e-registration systems for employees and digital registration and payment platforms for firms. Moreover, the wider use of e-government services may help reduce informality by lowering compliance costs and improving monitoring capacity. Addressing operational and legal challenges related to existing digital applications, such as e-ledger and e-invoicing systems, can further enhance their effectiveness (İbiş and Taytak, 2025). More broadly, strengthening audit capacity, including digital auditing tools, may improve law enforcement and increase deterrence against tax evasion and informal activities.

Lastly, inflation rates in Türkiye are generally high, highly volatile, and therefore need to be reduced to a reasonable level. Although implementing a tight monetary policy is the most fundamental instrument, it is not sufficient on its own. In Türkiye, fiscal policy should also support monetary policy in the fight against inflation. Given the strong domestic demand, implementing a contractionary fiscal policy together with a prudent exchange rate policy is essential to contain inflationary pressures (IMF, 2024). In this respect, coordinated monetary, fiscal, and incomes policies are crucial for reducing inflation. Moreover, productivity-enhancing policies may help address Türkiye's structural economic problems and, at the same time, contribute to lower inflation by reducing costs and increasing supply (Bulman and Simon, 2003).

This study has some limitations. First, data availability for innovation-related areas such as e-government and digitalization is quite limited for Türkiye and is not suitable for time-series analysis. For this reason, the study relies on a more general measure of innovation, without focusing on its sub-dimensions, using alternative indicators with a longer time coverage. Although this choice clearly constitutes a limitation, it also points to a promising avenue for future research, particularly for panel studies covering a larger set of countries.

Moreover, given the limited literature on the impact of innovation on the shadow economy, future research could examine this relationship across different country groups or at the global level to capture potential heterogeneity in the effects of innovation. In addition, while this study uses total R&D expenditure as a proxy for innovation, future studies may distinguish between public and private R&D expenditures or employ alternative proxies, such as patent-based indicators. Finally, future research may investigate the moderating role of government quality in the relationship between innovation and informality.

Declaration of Research and Publication Ethics

This study which does not require ethics committee approval and/or legal/specific permission complies with the research and publication ethics.

Researcher's Contribution Rate Statement

I am a single author of this paper. My contribution is 100%.

Declaration of Researcher's Conflict of Interest

There is no potential conflicts of interest in this study.

Declaration of Artificial Intelligence Usage

During the preparation of this work, the author(s) used OpenAI for the purpose of proofreading. After using this tool/service, the content was reviewed and edited as necessary, and the author(s) take full responsibility for the content of the published article.

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