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ABSTRACT

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The relationship between shadow economy (SE) and development has been extensively researched. However, there is a lack of consensus on the factors that drive reversals. This paper examines the effect of SE reversals when government collections are affected to changes in productivity, business regulations and financial depth. To this end, drawing on González *et.al.* (2005; 2017) Panel Smooth Transition Regression (PSTR), we examine the rationale of exclusion and escape theories in Advanced (AE) and Emerging and Developing Economies (EMD). Results show that at a macroeconomic level, both perspectives coexist simultaneously. In EMD, the optimal threshold for revenues hovers around 13.6% of GDP while in AE it equals 24%. The explanation for this is that institutional tensions lead to SE reversals when financial pressure is binding (e.g., more robust banking systems) facilitating the transactions in the formal channels and reducing the incentives for joining the SE. Conversely, when economies are above the critical tax level of revenues, financial pressure is binding and workers may voluntarily take part-time positions or jobs in units with lower required skills which explains the expansion of the SE. Evidently, the institutional has a direct effect over worker's productivity with mixed effects over tax collection.

KEYWORDS: shadow economy, tax collection, business entrepreneurship, threshold

JEL CODES: O17, O40, C23, C24

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1. Introduction

The relationship between shadow economy (SE) (also termed informal economy) and development has attracted a great deal of academic attention (Schneider and Entse 2002; Gërxhani 2003; Gillman and Cziraky 2004; Treisman 2007; Schneider 2011, 2015, 2016; Feld and Schneider 2010; Hassan and Schneider 2016; Medina and Schneider 2018; Schneider and Williams 2013; Wu and Schneider 2019). Perry *et al.* (2007) examine workers' incentives to seek employment in the SE, they find that the choice is attributed to workers' inability to earn high wages in times of market failure. Literature on the determinants of SE comprises a larger body of work with studies highlighting that individual incentives and remuneration impact workers' preference to seek employment in the informal sector. This, however, adversely impacts the economy's tax revenues and economic indicators, such as economic growth, unemployment and income distribution (Schneider 2011; Dell'Anno *et al.* 2007; Gërxhani 2003; Schneider and Enste 2000). Furthermore, new studies examining the link between SE and economic growth find that institutional quality, i.e., governance, level of corruption, bureaucratic quality, rule of law, and political stability, is an important driver of the size of SE with significant effects on poverty and government incentives (see, for instance, Dreher and Schneider 2010; Torgler and Schneider 2007; Berdiev *et al.* 2020 and Elbahnasawy *et al.* 2016). So far, the growing literature has mainly focussed on the implications of SE size on development.

To the best of our knowledge only few studies rationalise (though from separate strands) the formal/informal business entrepreneurship incentives through state regulations (Autio and Fu 2015); government size, potential entrepreneurship and market freedom conditional on a lower perception of corruption (Aidis *et al.* 2012); and workers' decisions to join the SE conditional on political interventions like a higher tax burden and/or limited financial access to markets (Goto and Mano 2012). However, from the developmental tax collection side none of the above-mentioned studies provide a quantitative threshold at which more productive workers may choose the SE instead of formal employment.

To fill this gap, we bring together recent evidence from Wu and Schneider (2019) and Fredström *et al.* (2021) to explain that SE reversals can be attributed to non-linearities in tax-collections which are very much related to labour productivity growth. This growth is linked to the degree of business freedom, government size, the perception of corruption, financial freedoms, all of which create a suitable environment for the efficient operation of firms (e.g., starting a business, obtaining a license, setting up infrastructure services etc.) and a higher depth of the financial system (e.g., private credit, pension funds/mutual assets to GDP etc.) which, in turn, entails a higher likelihood of remaining in the formal banking channels. Moreover, as Wu and Schneider (2019, 3-4) claim: *"when educational attainment reaches a certain level as GDP per capita hits a threshold, further increases in educational attainment not only push up GDP per capita but also reverses the declining trend of the shadow economy. This reversal could be attributed to the increase in the informal sector's salary due to the growing productivity level. When household revenue exceeds a critical level, financial pressure becomes less intense. Some family members may become more willing to take temporary unregistered assignments than formal full-time or part-time positions in exchange for flexibility, which leads to the expansion of the shadow economy".* To this end, we rely on the large body of entrepreneurship literature (see, for

instance, Acs and Varga 2005; Baumol and Strom 2007; Bruton *et al.* 2010; Gries and Naudé 2010; Kim and Li 2014; McMullen *et al.* 2008; Puffer *et al.* 2010; Stephan *et al.* 2015; Webb *et al.* 2020, among many others) to assess SE reversals as a function of tax collections, worker's productivity and business entrepreneurship.

It is important to stress that this paper does not consider the tax morale vision (Williams and Bezeredi 2018) nor the opportunity-to-necessity of informal/formal entrepreneurship due to institutional incongruences (Fredström *et al.* 2021). Instead, our concern here is to gauge the conditional effect of revenues over SE reversals. In other words, we hypothesise that above the optimal revenue threshold, country's institutional market inconsistencies (e.g., a higher perception of corruption, lower price stability etc.) may exacerbate tensions on rules, encouraging most productive workers to join the SE, thus forsaking formal labour markets. This can commonly be referred to as an 'escape' rationale in the micro labour literature. Conversely, we argue that below the optimal level of tax-collection, the majority of workers take for granted the costs of joining the SE: in this case an 'exclusion' vision may hold i.e., when GDP shrinks it seems natural to expect some workers unwilling to leave formal labour markets to be thrown out from the system. The same reverse analysis can be applied when economies expand: in this case workers stay in the formal labour markets. For those reasons, we argue that both visions can perfectly coexist. Albeit given the cross-country heterogeneity on tax legislations and social security support to informal workers, the final effect will ultimately depend on country's institutional extent and the 'remaining' unobserved factors that may influence the SE.

The empirical analysis in this paper is carried out through a Panel Smooth Transition Regression Model (PSTR) *à la* González *et. al* (2005; 2017) for Emerging & Developing (EMD) and Advanced Economies (AE). Results show that at a macroeconomic level, both perspectives coexist simultaneously. In EMD the optimal threshold for revenues hovers around 13.6% of GDP while in AE it equals 24%. When we break down the analysis results evidence that in EMD institutional tensions lead to large SE reversals compared to AE. We find that a higher financial depth provides a tipping point below as it reduces the incentives for joining the SE. When economies are above the critical tax level of revenues, then, financial pressures become binding and workers may voluntarily take part-time positions or jobs in units with lower required skills which explains the expansion. Evidently, the institutional environment has a direct effect over worker's productivity with mixed effects on tax collection. When we assess the stability of the PSTR estimates under endogeneity and cross-sectional dependence, results show that quantile methods outperform linear models (e.g., OLS, MO-OLS). However, the remaining heterogeneity cannot be removed completely as individual trends and latent groups could be at work.

The remainder of the paper is organised as follows: section 2 reviews the relevant literature. Section 3 discusses materials, while a descriptive analysis and the methodological approach are also exhibited. Section 4 presents the empirical findings. Section 5 offers concluding remarks and outlines the implications for policy making.

2. Literature review

SE is defined as "*economic activities, whether legal or illegal, which are required by law to be fully reported to the tax administration but not reported: as a result, these go untaxed unlike activities which are so reported*" (OECD 2017, 9). In other words, all economic activities that contribute to the

officially calculated (or observed) gross national product but are currently unregistered fall within the SE range. There is no currently universally accepted single definition of underground economy nor a common view on what really constitutes a SE activity, as pointed out by Schneider and Enste (2000), Giles and Tedds (2002), and Dell'Anno and Schneider (2003) mic. Further, there is a lack of unanimity on the estimation procedures employed for the economic analysis of the SE in a country (Schneider and Enste 2000; Feld and Schneider 2010; Besley and Persson 2010). At the same time the debate on the productivity and legal viewpoints on SE has also grown which features opposing views. On the one hand, the productivity view suggests that workers with lower qualifications are mostly employed informally in the sectors characterised by low capital-labour ratio (Fields 1990). On the other, the legal view opines that, in the absence of labour contracts, workers have no access to social security (i.e., retirement, pensions, health insurance, paid holidays etc.) which triggers the decision of workers to opt out from formal sectors and choose the SE. Both perspectives have shortcomings mainly because the productivity measurement of unregistered activities is problematic: as a result, the findings across countries are heterogeneous (Gasparini and Tornarolli 2007).

Literature presents two already outlined and non-mutually exclusive perspectives for employment in the SE: the 'exclusion' and 'escape' theories. Both explanations suggest that they can coexist simultaneously and depend on the economic cycles with their peaks and troughs. The 'exclusion' theory, which is grounded in labour economics, claims that market segmentation is a direct consequence of informality but it ends up modifying individual preferences and propensities so that some workers are unwilling to leave the informal economy, while others may have joined after being expelled when GDP shrank during a deep crisis. The 'escape' theory explains that the SE absorbs workers who have less chance of earning higher wages. Perry *et al.* (2007) attribute workers' decision to join the SE to their inability to earn high wages and market failures: this outcome is explained by several factors such as lack of minimum wages, excessively burdensome taxes, mismatch between skills available and required by the employers, as well as institutional weaknesses. Other reasons to choose the informal sector include heterogeneity of skills (e.g., different levels of human capital), preference of self-employed workers for 'time and freedom' and the comparative advantage of flexibility compared to traditional jobs. Others[1] instead find a steep decline (increase) in cross-national variations of informal employment conditional on higher tax revenues, government spending levels and a significant proportion of ultra-poor workers i.e., those living below the poverty line (Williams 2015). Along the collection lines, new evidence for Eastern European countries suggests that societies with a lack of institutional enforcements and trust (e.g., higher corruption among public officials, political instability, deficient public services and absence of tax-fairness and/or significant tax-burden) are more like to experience lower levels of tax-morale; and therefore, more entrepreneurs operating/joining the SE (Williams 2013; Williams and Bezeredi 2018).

Hirschman (1970) suggests that the informal sector is a consequence of a deliberate 'choice' by firms and workers. His study highlights the role of 'choice' and explains why workers join the SE and that their decision is linked to the level of skills and smaller benefits from social protection. For some

[1] Interestingly, earlier studies (see, for instance, Evans *et al.* 2006; Williams 2004; Williams and Windebank 2006) argue that the structuralist (i.e., the exclusion theory) and neo-liberal (the escape theory) visions are inversely related to the relative wealth of the working population. That is, more deprived societies are more likely to have a higher proportion of expelled workers than less deprived ones which may choose to join voluntary the SE.

workers, however, 'going informal' is an optimal choice because social and cultural benefits of being an entrepreneur, such as 'at-will holidays' lie within their optimisation frontier. Torgler and Schneider (2007) however state that "the violation of social norms is connected with higher costs of being active in the informal sector". Studies present mixed findings on the relationship between taxes and the size of the SE. Some show that low taxes lead to a smaller informal sector, which encompasses, in turn, higher tax revenue for governments, higher spending and provision of improved public goods with positive effects on economic growth (Gërxhani 2003; Loayza *et al.* 2009; Schneider and Enste 2000). Loayza (1996) highlights the negative impact of the SE on urban services by stressing that low tax collection due to the considerable size of the SE sector affects the government's ability to fund infrastructure projects. Diametrically opposite is Asea (1996) who states that "SE may increase financial resources, generate dynamic entrepreneurship and mould the necessary institutions for capital accumulation". In this vein, Hayek (1945) had already argued that the information on time and space allows entrepreneurs to create new markets. This, however, does not imply that all employment would necessarily be created by the SE. Interestingly however, Austrian schools academicians have also focussed on the role of government policies and resources. For example, De Soto (1989) discusses firms' responsibility to comply with the legal requirements and fiscal burden, and suggests that investment by the government in innovation and entrepreneurship leads to high-quality job creation. Studies also show that government policies segment markets between high and less qualified workers[2].

Other studies highlight the importance of institutional quality (e.g., good governance, level of corruption, bureaucratic quality, rule of law, political instability) as drivers of SE (Dreher and Schneider 2010; Dreher *et al.* 2009; Elbahnasawy *et al.* 2016; Torgler and Schneider 2007). Acemoglu and Robinson (2002) outline the importance of institutions and their knock-on effect on the growth and development processes much in the spirit of Kuznets (1955). The entrepreneurship (institutional) literature shows that factors are positively associated to a higher degree of private property protection, lower entry costs, bankruptcy procedures, corporate entry regulations if legal origins rules are English, German or Scandinavian while in Socialist regimes or less developed financial systems the effect is mostly negative (see, for example, Demirguc-Kunt *et al*. 2006; Desai *et al*. 2003; McMullen *et al*. 2008). Along the same institutional lines, Aidis *et al.* (2012) find that business networks are stronger in countries whose institutional environment create positive synergies by fostering and complementing private productivity and reducing transaction costs through a higher respect of contracts[3].

[2] A note of caution must be added here: if entrepreneurs try to preserve their profitability by cutting labour costs, this segmentation will not happen simply because there will be no highly skilled position to apply for. On the contrary, the role of the State is useful if it focusses on building highly competitive sectors and enterprises through public investment.

[3] In this case, an excessive governmental support (e.g., infrastructure spending, welfare programs, tax incentives) and /or additional improvement on the perception of corruption may bring a conflict i.e., a trade-off between 'too many' entrepreneurs. However, as explained earlier, this paper does not deal with the opportunity-necessity motive of being a formal/informal entrepreneur as the combination of macro-economic factors are intimately related with country income levels (for a more recent discussion of the main drawbacks of the formal/informal entrepreneurship definitions see Laing *et al.* 2021).

Accordingly, literature indicates that better (worse) institutions provide stronger (weaker) incentives to workers/firms to behave legally (illegally) and increase (decrease) the cost of illegal activities from greater institutional accountability. Studies find evidence of small SE in developed countries. For example, in Western European countries which belong to the Advanced Economies (AE) group, the size of the SE ranges between 10-20% of the GDP on average; but in Eastern countries, the extent is considerably much higher (between 30-35 %). However, it is worth stressing that since 2000's, the SE has grown in Croatia, Cyprus, Greece, Serbia, but declined in Czech Republic and Macedonia. Oppositely, the evidence for developing countries indicates that the size of the SE decreased. For instance, focussing on Latin America, Tornarolli *et al.* 2014 find that labour informality between 1990-2010 declined in most countries with the exception of El Salvador and Mexico, although there is some inertia concerning workers' decisions to leave the SE regardless a recovery of the economy. But as explained earlier, the size of the SE is linked to the economic cycles. In this line, more recent evidence indicates that the size of the SE in EU countries increased during the Great Recession period (2008-2010) but declined to its pre-crisis level in 2015 (Kelmanson *et al.* 2019). Likewise, the same trend is also observed in Latin American countries. For example, Bergolo and Cruces (2021) show that formal employment in Uruguay grew from more than 52% to 60% in 2012 while informal ones declined from 25.1% and 22.6% for the post-crisis period (2008) and increased from 17.8% to 22.2% in 2012, respectively. Interestingly, the authors find that the timing in terms of declines (i.e., inactivity) from formal to informal jobs are equally weighted between workers.

3. Materials and data sources

This paper draws on Elgin *et al.* (2021) shadow economy data for the 1993-2018 period. We use the MIMIC measure as it captures closely the size of the SE (Schneider 2010, 2015; Feld and Schneider 2010; Abdih and Medina 2016; Vuletin 2009; Williams and Schneider 2016; Medina and Schneider 2018). However, we have also considered the Dynamic general equilibrium model-based (DGE) estimates which include pre-1993 years.

For what concerns tax collections, we rely on the Government Revenue Database (GRD). In particular, due to data limitations, we take the average revenue (% GDP) from both central and general governments excluding grants and social contributions. For the present study, we include several developing indicators as additional controls, namely: labour productivity, per capita GDP in usd at PPP in 2020, GDP growth rate (Conference Board); mean schooling years (Human Development Reports); gross capital formation (% GDP), population annual growth (World Development Indicators) and financial depth index (International Monetary Fund).

Last but not least, building on McMullen *et al*. (2008) Aidis *et al.* (2012), we use the institutional indicators from the Heritage Foundation which are graded on a scale from 0 to 100 from a weighted average on sub-categories. Our main variable of interest to test the 'exclusion' and 'escape' perspective is business freedom which we can be a good proxy of entry barriers to start, operate or close a business. This measure seems appropriate given that our major concern is related to SE reversals in regards to changes in productivity and collections at a macroeconomic level. Unfortunately, data is available from 1995 onwards and for some countries there is no information. For those reasons we restrict our analysis to the 1996-2018 period. Finally, we create dummies for

English, German, Scandinavian commercial codes and an indicator variable of economic cycles which can be considered a good proxy of market segmentation. To this end, we employ the well-known Hamilton (2018) filter which separates the trend from the cycle while at the same time avoiding the spurious dynamic implied by the Hodrick-Prescott filter. The detrended Real GDP cycle is a paramount ingredient both for the SE and revenues to capture their dynamics during troughs, expansions, peaks, or contractions[4]. Overall, the final dataset comprises 75 developed and developing economies (32 vs. 43 countries respectively). The complete list of countries and the definition of variables can be found in the tables 1 and 2 of the annex.

3.1 Descriptive statistics and stylized facts

The SE ranges between 11.1% and 60.6% as a proportion of GDP for EMD while in AE countries SE size is 8.0% and 34.1% respectively (table 1). For the first group, the average size is 36% on average while in more developed economies less than 19% in the twenty-three year time span analysed. Interestingly, GDP per capita, total tax revenues (general and central) to GDP and labour productivity growth also display mixed results. For instance, per capita GDPs in US$ measured at PPP are $11,900 and $45,100 for EMD and AE respectively. Revenues (as a proportion of GDP) are 20% and 28% for EMD and AE whereas labour productivity growth is higher in the EMD with respect to AE (2.4% vs 1.5%). However, the standard deviation of both SE and revenues is more than twice for the first group of countries which suggests that workers' transitions from the formal to the informal sector can have sizeable effects in terms of taxes due to the heterogeneity of tax-collection systems.

Accordingly, following Aidis *et al.* (2012) we hypothesise that a higher perception of corruption (government integrity), entry barriers to start or to allow the normal functioning of business and a lower size of a government may exacerbate labour market tightness through a fall in search rates or a decrease in formal registrations, thus encouraging most productive workers to join the SE. For example, in table 1 government integrity mean score (in a 100 basis) where 0 is the minimum and 100 the maximum in AE is almost twice than EMD (75 vs. 35, respectively). Interestingly, EMD government spending and/or tax burden average scores in EMD are considerably much higher than those of AE: 75 vs 41, and 76 vs 61 respectively, while business freedom reaches to 80 points in AE and 61 in EMD. As discussed above, once corruption amongst public officials increase, any attempt by the government to increase public spending will be highly ineffective and unproductive, and this creates tensions for the normal functioning of private businesses (a school case of waste of public finances). Therefore, more productive workers in EMD choose to 'escape' from the formal into the informal economy[5]. Conversely, lower corruption in AE coupled with productive public spending sends a positive signal to

[4] Other studies (see, for example Radetzki 2006 and Humphreys 2019) focussed on the commodity price boom (2003-10) and the Great financial crisis (2007-2009) periods as proxies of volatility over the output.

[5] Certainly, a pool of less productive workers could also choose the SE given their skills and human capital abilities. Of course, at a microeconomic level some occupations are easily related to informal jobs as these are typically identified by activities like the "Jua Kali" artisans and metal workers working under the sun back in 1980's. In this vein, one of the drawbacks of working with macroeconomic series is that it hinders detailed information, leaving only differences in salaries growth at purchasing parity levels (PPP).

markets as it indicates the presence of substantial 'checks and balances' which can be associated to a higher labour flexibility[6].

Oppositely, in AE higher scores on business freedom and corruption are negatively related to the SE as the overall effect offsets the positive coefficient of government spending. From these results, we confirm that the existing institutional tensions encompass macroeconomic effects over tax collections and the SE. Yet, in macro-panels cross-section covariance of the errors is usually different from zero. is the implication of the presence of this particular covariance determines the biasedness of standard panel methods which also end up being plagued by cross-sectional dependence and omitted bias issues due to the unobserved heterogeneity amongst units, an issue addressed in our robustness controls (see section 4.1 for further details).

Table 1. Summary statistics: 1996-2018

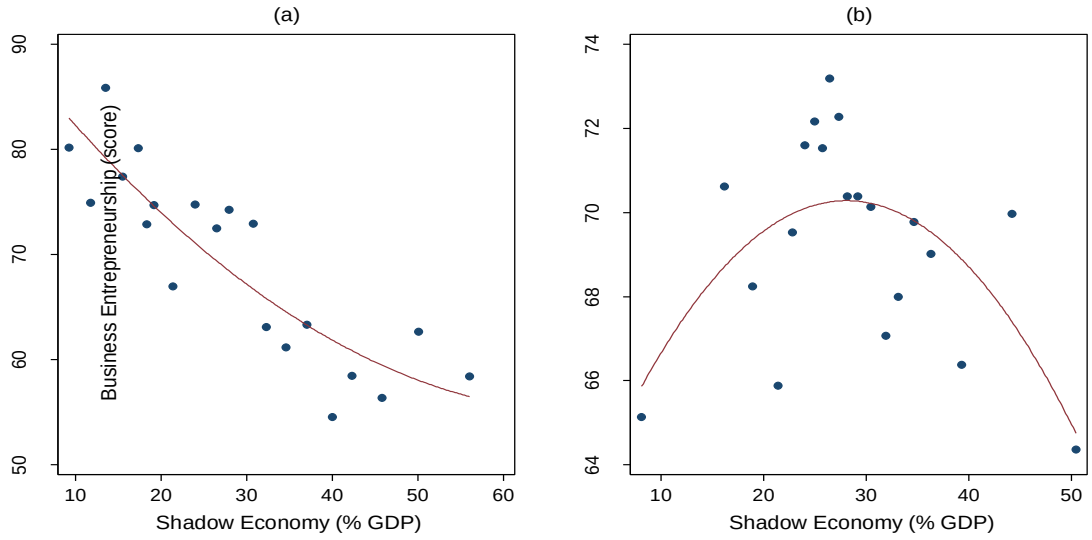
Variables	AE				EMD			
	Mean	SD	Min	Max	Mean	SD	Min	Max
Shadow economy (% GDP)	18.900	6.797	8.065	34.120	35.940	11.910	11.170	60.600
Total Revenue (% GDP)	28.030	6.579	14.710	48.800	20.120	10.380	5.213	84.700
GDP (PPP) growth rate	2.696	3.074	-14.840	14.530	4.500	3.827	-15.100	34.470
GDP (PPP) per capita	45,099.500	17,739.900	10,425.600	121,525.300	11,927.800	12,923.600	549.000	83,648.200
Capital formation (% GDP)	23.750	4.443	11.890	41.590	24.310	7.671	1.157	79.400
Labour productivity growth	1.565	2.442	-7.786	12.990	2.419	4.060	-14.250	32.860
Financial depth (index)	0.611	0.246	0.052	1.000	0.181	0.180	0.010	0.885
Population growth rate	0.567	0.859	-2.233	5.448	1.663	1.327	-3.144	14.700
Mean schooling (years)	11.320	1.463	6.500	14.100	7.082	2.704	0.900	12.300
Business Freedom (score)	80.490	9.862	55.000	100.000	60.950	11.490	28.800	93.500
Financial Freedom (score)	69.970	14.520	30.000	90.000	48.210	14.380	10.000	70.000
Investment Freedom (score)	74.520	12.000	30.000	95.000	51.320	16.180	10.000	90.000
Monetary Freedom (score)	82.070	6.742	12.900	94.300	73.100	12.380	0.000	91.900
Trade Freedom (score)	82.390	5.795	55.000	90.000	66.790	14.830	0.000	88.700
Tax Burden (score)	61.330	14.280	29.800	93.600	75.920	11.470	36.600	99.900
Government Spending (score)	41.490	21.350	0.000	95.300	74.950	17.840	0.000	97.500
Government Integrity (score)	70.580	18.800	10.000	100.000	34.960	14.690	4.000	79.000
Property Rights (score)	78.650	14.300	30.000	98.400	43.380	17.190	10.000	90.000
Economic Freedom (score)	70.870	7.304	49.700	89.400	58.770	7.489	30.000	79.000
Number of observations	736				989			
Number of countries	32				43			

Source: Authors' calculations

[6] On a general basis, the inclusion of the employment protection index yields a positive association between business entrepreneurship and the SE. However, this variable is measured for different categories of workers and different firm size (e.g., blue collars, white collars, large and small enterprises). Furthermore, employment protection is heterogeneously among countries. Thus, to ensure comparability we have decided to exclude it from the analysis.

Next, we document some key empirical patterns of the non-linear relationship between the SE and the above-mentioned institutional variables conditional on labour productivity. Figure 1 (panel a) shows that business freedom is negatively related to the SE: in other words, after accounting only for time fixed-effects, a higher score given by lower entry barriers to operate and start a business reduces the incentives to join the SE. However, after controlling for labour productivity, government size and integrity (aka, corruption, panel b), results show an inverted u-shape pattern. This suggests a possible trade-off between the "optimal number of entrepreneurs" and the decreasing benefits of being an entrepreneur in the formal economy. Interestingly, we observe the same trend between business entrepreneurship and SE when English, German, Scandinavian commercial codes and financial depth are considered. For the sake of space, this relation is only available upon request.

Figure 1. Non-linear relationship between entrepreneurship, shadow economy and institutions: 1996-2018



Note: we regard business freedom as a proxy of entrepreneurship. In order to wipe out the unobserved heterogeneity and control for economic cycles, we employ the fixed-effects (within) transformation for the full sample of countries (75 countries). Panel (a) only includes time fixed-effects whereas in panel (b) time fixed-effects, labour productivity growth, government size and integrity (i.e., perception of corruption) are included as additional controls.
Source: Authors' calculations

In regards to entrepreneurship, as discussed earlier, lower entry barriers might amplify the existing tensions with government size and the perceived corruption. To this end, we employ an appropriate Panel Jackknife (HPJ) heterogeneous Granger test[7] (Juodis *et al.* 2021a) to check for causality links. Results (available upon request) confirm the existing (temporal) tension among the institutional variables and the SE.

[7] Compared to the existing methodologies for heterogenous panels (see, for instance, Dumitrescu and Hurlin 2012), the HPJ test does not suffer from substantial size distortions (i.e., 'Nickell bias'), especially when T<N (like the present paper). Under this framework, the bias is removed by comparing the maximum-likelihood estimates from the full panel with sub-panel blocks with fewer observations.

Interestingly, a more robust financial system under English, German or Scandinavian commercial codes is positively related to the SE in all groups. On the other hand, the interaction between the above mentioned commercial codes and financial depth, is stronger in Emerging and Developing economies compared to more advanced ones whereas for business freedom coefficients are significant only in developed countries although these are close to zero. Overall, our causality tests suggest that a higher financial depth indeed fosters entrepreneurship. Yet, 'too many' entrepreneurs may reduce government revenues as too many people may operate in the informal sector, government size (measured through spending) with possible mixed effects over the perceived levels of corruption by workers. For those reasons, our model accounts for non-linearities only from tax collections and SE conditional on business freedom, financial depth, government size and integrity for which productive workers might choose to join the SE with respect to the formal economy. In empirical grounds our analysis hinges on the estimation of transition functions associated to lower and upper revenue regimes. Nevertheless, prior to presenting the regression analysis, we explore the within pairwise fixed-effects and intra-class correlations, potential multicollinearity and cross-sectional dependence amongst the variables of interest for our macro panel.

3.2 Panel analysis

Table 2 column (a) shows the intra-class (ICC) and pairwise within correlations for all the 75 countries 75. At first sight, individual clustered variance correlations indicate that within-group variability is more important than between-group variability. This would lead us to think that observations might be a priori regarded as independent. Similarly, after removing the country-year fixed effects, pairwise of all within transformed variables are statistically significant and have the expected signs. For instance, tax revenue, labour productivity, GDP growth, capital formation, government size and integrity are negatively correlated to SE. In the case of business entrepreneurship and freedom to invest, the correlations for the whole sample are mixed. However, once we break down the analysis by groups (available upon request), results confirm the existing institutional tensions in more advanced economies between lower entry barriers to operate and start a business, a higher financial development and the SE. In other words, there is a trade-off between the 'optimal number entrepreneurs' or decreasing benefits of being an entrepreneur; thus, productive workers may be tempted to 'escape' from the formal economy. Conversely, in developing economies there is a negative association between business entrepreneurship and the SE, which might mean that economic cycles may partially offset workers' incentives and personal decisions to leave the formal economy regardless of their human capital skills. Therefore, in the EMD case, the 'exclusion' view (a priori) could be more appropriate at a macroeconomic level. Overall, these cross-sectional relationships indicate that both visions can perfectly coexist. Likewise, after the within fixed-effects transformation, relationships persist although the correlation magnitude is generally reduced but yet continue to be significant. Columns (b) of that same table shows the individual Variance Inflation Factors (VIF) and Tolerance. As it can be observed, multicollinearity is ruled out as the mean (VIF) and the condition number on the eigenvalues are below their respective rules of thumb (10 and 15 respectively). The same occurs with Tolerance which is always way higher than the 0.1 threshold. The highest VIF values were 2.95 and 2.87: clearly, none of those two figures will compromise the regression models. Finally, columns (c) presents the cross-sectional dependence test and its p-value

beside. As it is evident in almost all macroeconomic panels, we reject the null hypothesis of weak cross-sectional dependence against the alternative of the presence of a strong one. Hence, the covariance of the majority of the variables involved in our panel is different from zero. Due to the CSD being statistically different from zero, inference using standard panel data methods will lead to biased estimates as the unobserved heterogeneity is substantial.

Table 2. Variance inflation factors (VIF), intra-class (ICC), country (within) correlations and cross-sectional dependence (CSD): 1996-2018

Variables	(a) Intra-class and country-within correlations		(b) Multicollinearity		(c) Cross-sectional dependence	
	ICC (rho)	Correlations	VIF	Tolerance	CD-statistic	p-value
Shadow economy (% GDP)	-	1	1.280	0.781	125.435	0.000***
Total Revenue (% GDP)	-	-0.118***	1.110	0.902	17.010	0.000***
GDP (PPP) growth rate	0.392	-0.162***	2.950	0.339	54.820	0.000***
GDP (PPP) per capita	-	-0.149***	1.310	0.766	188.253	0.000***
Capital formation (% GDP)	-	-0.241**	1.140	0.880	14.953	0.000***
Labour productivity growth	-	-0.078***	2.870	0.348	32.067	0.000***
Financial depth (index)	0.973	-0.042*	1.130	0.888	103.584	0.000***
Population growth rate	-	-0.016	1.080	0.923	3.326	0.000**
Mean schooling (years)	0.337	0.026	1.100	0.907	219.631	0.000***
Business freedom (score)	0.315	-0.015	1.100	0.912	6.077	0.000***
Financial freedom (score)	0.279	-0.057**	1.110	0.897	-0.250	0.802
Investment freedom (score)	0.279	0.045*	1.110	0.905	28.839	0.000***
Monetary freedom (score)	0.200	-0.289***	1.220	0.822	64.137	0.000***
Trade freedom (score)	0.362	-0.079***	1.080	0.924	176.207	0.000***
Tax burden (score)	0.205	-0.081***	1.160	0.865	73.282	0.000***
Government spending (score)	0.211	-0.094***	1.120	0.894	22.864	0.000***
Government integrity (score)	0.495	-0.218***	1.150	0.868	0.200	0.841
Property rights (score)	0.518	0.025	1.190	0.841	21.550	0.000***
Mean	-	-	1.345	0.814	-	-

Note: (a) for the sake of space, we only report the multicollinearity, intra-class-correlations and cross-sectional dependence test for the full sample of 75 countries; (b) VIF values greater than 10 indicate reasons for concern due to collinearity among variables. Tolerance values less than 0.1 indicate collinearity among variables. From our (centred) values we can infer that the majority of variables do not suffer from collinearity once we remove economic freedom (overall score). Another useful rule of thumb to check for the presence of multicollinearity is the condition number of the eigenvalues below 15. In our case, the condition (not reported) is 3.425 which falls within that rule; (c) we employ the CSD test of Juodis and Reese (2021). Results show that the null hypothesis of (weak) CSD against strong one is rejected at 1% for almost all variables. ***,**,* indicate statistical significance at 1, 5 and 10 percent level respectively.
Source: Authors' calculations

For the above-mentioned reasons, our econometric approach proceeds as follows: first, following the existing literature on PSTR and non-linear models (Colletaz and Hurlin 2006; Fouquau *et al.* 2008; López-Villavicencio and Mignon 2011; Béreau *et al.* 2012; Duarte *et al.* 2013, Jude and Levieuge 2015; Doumbia 2018; Ben Cheikh and Ben Zaied 2020) we estimate a Panel Smooth Transition Regression (PSTR) à la González *et al.* (2005; 2017). Particularly, our study contributes to the growing empirical literature on both business entrepreneurship and SE (Desai *et al*. 2003; Demirguc-Kunt *et al*. 2006;

McMullen *et al*. 2008; Aidis *et al.* 2012; Wu and Schneider 2019; Fredström *et al.* 2021, among many others). In empirical grounds, the use of PSTR allows to unpack different regimes and transition functions associated to potential thresholds. In this way, the model controls for the unobserved heterogeneity while accounting for the endogeneity problem and the omitted variable bias issue (Fouquau *et al.* 2008; Béreau *et al.* 2012; Yu 2013).

Nonetheless, simplicity comes at a cost. Unfortunately, macro panels are plagued by cross-sectional correlation issues and reverse causality when the lagged dependent variable is included as an additional regressor. We depart from Duarte *et al*. (2013) and apply the so-called Mean Observation OLS (henceforth MO-OLS algorithm proposed in Keane and Neal (2020) and Neal (2016) which takes into account slope heterogeneity and cross-sectional dependence and can be adapted to balanced and unbalanced panels. As explained by the authors, the MO-OLS technique yields consistent estimators but it requires strict exogeneity of the regressors as well as stationarity. However, if the unobserved heterogeneity is caused by time-varying slope parameters, then, MO-OLS will be more effective in removing cross-sectional dependence than the Common Correlated Pooled Estimator (Pesaran 2006). For those reasons, we address both issues (endogeneity and cross-sectional dependence) using time varying interaction terms between endogenous and exogenous binary variables (for more details of this strategy see Beverelli *et al*. 2018; Dreher *et al*. 2021; Nizalova and Murtazashvili 2016). The rationale for the statistical approach applied here is that the exogenous component of the interactions effectively reduces the correlation of the (confounding) endogenous covariates and the dependent variable.

Finally, we assess the stability of the individual parameters of the final (extreme) regime (β_1) under PSTR with respect to the pooled OLS (POLS) with time-dummies and interactions and the two-step quantile estimator of Canay (2011). This two-step procedure provides a flexible approach to capture the unobserved heterogeneity from fixed-effect models. In the former stage, all the individual effects are estimated by using the standard (within) fixed effects estimator for linear panel data. In the second stage, the recovered coefficients are estimated by standard quantile regressions (i.e., treating the estimated individual effects from the first stage as given). For what concerns our robustness checks two things are worth stressing. First, we assume that regime transitions remain stable across the period under analysis. Second, the statistical approach using interactions between endogenous and strictly exogenous regressors ameliorates the endogeneity which can be persistent even after controlling for the remaining (unobserved) heterogeneity.

The choice of the aforementioned techniques is not trivial and in what follows we provide a brief explanation of why other techniques have been ruled out in the analysed context. To begin with, it must be clear that literature for both static and dynamic thresholds is not the panacea as these models rely on the strong assumption of cross-sectional independence of the unobserved error terms (Seo and Shin 2016). Moreover, dynamic thresholds for heterogenous panels (Chudik *et al*. 2017) cannot be applied in our framework as this technique requires a T=30 to form a sufficient number of cross-sectional averages and control for all the unobserved common factors. To make things worse, neither the Common Correlated Mean Group (CCMG), the Common Correlated Pooled (CCEP) nor the Augmented Pooled-Mean-Group (AMG) estimators, which accommodate to large heterogeneous panels with cross-sectional dependence, can rule out reverse causality or serial correlation (see, Pesaran 2006; Eberhardt and Teal 2010). In this vein, in the case of different threshold values, pooling individuals would bias the parameters and the slope heterogenous coefficients. In addition, this can

even fail in detecting any threshold effects which will ultimately lead to inconsistent estimates under the presence of latent groups (Miao *et al.* 2020)[8]. Finally, the Fully Modified OLS (FMOLS) estimator of Phillips and Hansen (1990) which is known to have desirable properties in terms of super-consistent estimates coupled with AMG and cross-sectional averages, cannot be applied as these require among other things first order integration of all variables involved or common long-run trends. Moreover, in spite of the correct choice of homogeneous/non-homogenous cointegration vectors, the CCEP estimator may yield very different results with respect to its Mean Group counterpart (Kapetanios *et al.* 2011).

3.3 Methodological approach

Panel Smooth Transition Regression Model (PSTR)

PSTR provides a parametric approach of the cross-country heterogeneity and the time variability of the slope coefficients of the variable of interest. Compared to polynomial and/or linear models with interactions, it allows parameters to change gradually as a function of the threshold transition variable (q_{it}). Therefore, coefficients can take different values, depending on the value of other (observable) covariates. This facilitates the identification of heterogeneous parameters in non-linear frameworks. PSTR first introduced by González *et al.* (2005), can be considered a generalisation of the Panel Threshold Regression of Ho (2003) and the panel linear model with individual fixed effects of Corbin (2001). In plain words, PSTR assumes a single transition function which is displayed for different slope parameters γ. When γ tends to infinity, the transition function $g(q_{it};\gamma,c)$ tends towards an indicator function equal to one and the model converges to the PTR of Hansen (1999). Conversely, when γ tends to zero, the transition function is constant and the model collapses to the standard linear within model with individual fixed effects and homogenous coefficients (Colletaz and Hurlin 2006; Fouquau *et al.* 2008)[9]. Empirically, PSTR operates as follows: firstly, it eliminates all the individual effects μ_i by removing the specific means; secondly, it applies non-linear least squares to the transformed model.

Model specification

For our empirical estimation, we estimate the simplest case that takes into account two regimes and two transition functions at most as there are no elements in the theoretical and empirical literature that justifies only one transition. Following González *et al*. (2017), the transition function $g(q_{it};\gamma,c_j)$ of the PSTR depends on a variable denoted q_{it} and can be parametrised using the logistic function:

$$fg(q_{it};\gamma,c) = \left(1 + exp\left(\left(-\gamma\prod_{j=1}^{m}(q_{it}-c_j)\right)\right)\right)^{-1} \quad with\ \gamma > 0\ and\ c_1 \le c_2 \qquad (1)$$

[8] As authors explain, closed formed solution for both endogenous regressors and latent factors for a PSTR require a different treatment as multiple thresholds could be at work.

[9] It is worth stressing that the PSTR parameters cannot be directly interpreted as elasticities. As in probit or logit models, it is preferable to assess the sign of the coefficients which may indicate an increase or a decrease in the variable of interest.

Where j refers to (the maximum number of) transitions, i refers to the countries and t is time. In this case j is limited to up to regimes as explained above: c_j and γ are the location parameters and threshold value respectively. The slope of the transition function determines the change between different regimes. The transformed explanatory variables (if any) z_{it} will not enter into the nonlinear part of the model. Therefore, coefficients will be constant.

In the case of one transition function and one regime ($r = 1;\ m = 1$), the PSTR captures a monotonic change in the coefficient of interest from β_0 to $(\beta_0 + \beta_1)$ which is a function of $g(\mathrm{q}_{it}; \gamma, c)$ as q_{it} increases. At the extremes, the coefficient of a variable is β_0 if the transition function is equal to 0 and β_1 if the transition function is equal to 1.

In the case of two regimes ($m = 2$) and assuming ($c_1 = c_2 = c$), the function achieves a minimum at $(c_1 + c_2)/2$ and it implies a symmetric change in parameter around $q_{it} = c$. In general, when $m > 1$ and γ tends to infinity, although the number of distinct regimes remains always two, with the transition function switching back and forth between zero and one at $c_1 \ldots c_m$. Finally, as stated by González *et al.* (2005), the PSTR requires stationarity of all variables in order to avoid the well-known spurious regression problem. In our case, we report the results of the second-generation panel unit root tests in table 3 of the annex. The Im *et al.* (2003), Levin *et al.* (2002) and the Phillips and Perron (1988) tests reject the null hypothesis of the existence of panel unit root at the 1% level of significance in favour of stationarity for all the variables with the exception of SE which will enter in first differences. Accordingly, following Fouquau *et al.* (2008) we employ the following specification:

$$\Delta SE_{it} = \mu_i + \beta_0^0 RV_{it} + \beta_1^0 X_{it} + [\beta_1^0 RV_{it} + \beta_1^1 X_{it}]\, g\big(RV_{it}, \gamma_j, c_j\big) + [\beta_2^0 RV_{it} + \beta_2^1 X_{it}]\, g\big(RV_{it}, \gamma_j, c_j\big) + \varepsilon_{i,t} \quad (2)$$

where the dependent variable $\Delta SE_{i,t}$ in first differences is SE expressed in percentage of GDP; the threshold variable RV_{it} is the total revenue of the economy from both general and central government (again expressed in percentage of GDP) excluding grants and social contributions and X_{it} is a vector of development and institutional controls: labour productivity per worker growth, real GDP growth rate at PPP, financial depth, population growth, mean schooling years, business freedom, government size, integrity and a dummy for economic cycles as discussed above. The superscripts 0, 1 and 2 indicate the number of transitions for each regressor at different times and ε_{it} is the error term. Notice that we have considered that all thresholds functions share the same variables. If all γ_j tend to infinity, then the generalised model applies and each variable may contain a different threshold value. In empirical grounds, the Fisher test for regime specifications (LM_F) which is explained below will determine automatically the number of optimal thresholds and regimes in our model.

Linearity and Specification tests

***Homogeneity test*.** Before estimating the PSTR model, we test the linearity (homogeneity) hypothesis against the alternative of a PSTR model. To this end, our null hypothesis is H_0: $\beta_1 = 0$ against H_1: $\beta_1 \neq 0$. As González *et al.* (2017) explains, the PSTR is not identified as it contains unidentified nuisance parameters which are sensitive if the data generating process is homogeneous. For those reasons, authors suggest replacing the transition function $g(q_{it}; \gamma, c)$ by its Taylor expansion around $\gamma = 0$. Accordingly, the null hypothesis can be restated as a function of only γ i.e., H_0: $\gamma = 0$ and equation (2) can be rewritten as:

$$y_{it} = \mu_i + \beta_0^{*\prime} X_{it} + \beta_1^{*\prime} X_{it} q_{it} + \ \ldots + \beta_m^{*\prime} X_{it} {q_{it}}^m + \ \varepsilon_{it}^* \quad (3)$$

where the parameter vectors $\beta_1^{*\prime}$ … $\beta_m^{*\prime}$ are multiples of γ and ε_{it}^* is equal to ε_{it} plus the remainder of the Taylor expansion times $\beta_1^* X_{it}$. Therefore, after this transformation, linearity can be tested using standard tests. Using the SSR (Sum Squared of Residuals) under the H_0 (linear panel model with individual effects) and SSR_1 (Sum of Squared of Residuals) under the alternative H_1 of PSTR, we can write the LM Wald, LMF and Likelihood Ratio (LR) tests as:

$$LM_W = \frac{NT(SSR_0 - SSR_1)}{SSR_0} \tag{4}$$

where N is the number of cross-units and T represents the time.

$$LM_F = \frac{NT(SSR_0 - SSR_1)/mk}{SSR_0/(TN - N - mk)} \tag{5}$$

where k is the number of explanatory variables used in the model and m is the number of thresholds in the transition function. The LM_F statistic follows a Fisher distribution in mk and $TN - N - mk$ degrees of freedom. Therefore, linearity is tested through a Chi-2 distribution with k degrees of freedom under the null hypothesis. It is worth stressing for small samples, the LM_F statistic has better size property with respect to its F version (Colletaz and Hurlin 2006). For those reasons, we only report the LM_F and LR. Table 3 panel (a) shows that the hypothesis of linearity is rejected at the 5% significance level for all countries and AE while in EMD only at 10% level. Therefore, results suggest that the relationship between SE and revenues is nonlinear.

Number of regimes. In order to identify the required number of transitions associated to the non-linear estimation, we rely on the Fisher statistic LM_F and the likelihood ratio LR statistic to test the linear against the remaining non-linear part. In our case, we concentrate on the two-regime case through the following hypothesis:

$$H_0: r = 1 \; vs \; H_1: r = 2 \;\; with \, m = 2 \qquad\qquad with \, r^* = 2$$

where r^* is the maximum number of thresholds allowed as explained earlier. Table 3 panel (b) confirm again that the specification hypothesis suggested by the LM_F statistic of one regime against two is rejected only at 10%. This means that the relationship between SE and Revenues has one threshold with at least two extreme regimes.

Table 3. Homogeneity and specification tests

Panel (a): Linearity	All countries	AE	EMD$^{\phi}$
LM_F	1.631**	1.927**	1.413
	(0.045)	(0.012)	(0.117)
LR	30.761**	0.012**	26.747*
	(0.031)	(0.006)	(0.084)
Panel (b): number of regimes	$r = 1$ vs $r = 2$	$r = 1$ vs $r = 2$	$r = 1$ vs $r = 2$
LM_F	1.586*	1.422	1.450
	(0.056)	(0.114)	(0.101)
LR	30.247**	27.675*	27.985*
	(0.035)	(0.067)	(0.062)

Note: ϕ Excluding Kuwait (outlier). p-values are presented in parenthesis. ***,**,* indicate statistical significance at 1, 5 and 10 percent level respectively.
Source: Authors' calculations

4. Discussion

Table 4 presents the results of the PSTR model for both regimes. Panel (a) shows the parameter estimates for the lower regime (i.e., below the threshold).

Table 4. Shadow economy and tax revenues: Panel Smooth Transition Regression Results (1996-2018)

Variables	**All countries**	**AE**	**EMD$^{\phi}$**
	Panel (a): Parameter estimates first regime (β_0)		
Labour productivity growth	-0.048*	-0.009	-0.046*
	[-1.774]	[-0.725]	[-1.710]
GDP growth rate	0.041*	-0.062***	0.040*
	[1.740]	[-6.785]	[1.704]
Population growth rate	0.218*	0.017	0.191
	[1.910]	[0.332]	[1.664]
Mean schooling years	-0.012	-0.092***	-0.020
	[-0.273]	[-5.040]	[-0.385]
Financial depth (index)	-3.905**	0.128	-3.879**
	[-2.478]	[0.635]	[-2.477]
Business freedom (score)	0.009	0.006**	0.009
	[1.631]	[2.352]	[1.506]
Government spending (score)	-0.006	0.005**	-0.006
	[-0.849]	[2.884]	[-0.947]
Government integrity (score)	-0.008	-0.001	-0.009
	[-1.546]	[-0.334]	[-1.641]
Economic cycle (dummy)	0.199**	0.007	0.200**
	[2.154]	[0.144]	[2.228]
	Panel (b): Parameter estimates final regime (β_1)		
Labour productivity growth	0.054*	0.029*	0.049*
	[1.905]	[1.974]	[1.698]
GDP growth rate	-0.132***	-0.046***	-0.130***
	[-5.361]	[-4.020]	[-4.970]
Population growth rate	-0.155	0.100*	-0.169
	[-1.361]	[1.971]	[-1.477]
Mean schooling years	-0.041	0.052**	-0.043
	[-0.942]	[2.951]	[-0.982]
Financial depth (index)	3.713**	-0.338*	3.651**
	[2.356]	[-1.829]	[2.324]
Business freedom (score)	-0.009	-0.006*	-0.009
	[-1.506]	[-2.017]	[-1.527]
Government spending (score)	0.010	0.000	0.011*
	[1.636]	[-0.049]	[1.760]
Government integrity (score)	0.008	0.002	0.008
	[1.544]	[0.755]	[1.475]
Economic cycle (dummy)	-0.170*	0.020	-0.171*
	[-1.775]	[0.372]	[-1.690]
Location parameters (c_i)	(12.960; 14.212)	(22.479; 25.528)	(12.960; 14.210)
Transition function $(c_1 + c_2/2)$	13.6%	24.0%	13.6%
Smoothing parameter (γ)	8.056	124.062	4.913
Thresholds (r^*) and Regimes (m^*)	(1, 2)	(1, 2)	(1, 2)
Number of parameters	19	19	19
AIC criterion	-1.930	-3.222	-1.456
BIC criterion	-1.930	-3.091	-1.350
Number of countries	75	32	42

Note: tax revenue (transition function) is expressed in level i.e. (to GDP). Dependent variable is the first difference of Shadow economy (to GDP). ϕ Excluding Kuwait (outlier). The corresponding t-statistics (robust to heteroskedasticity) of the heterogenous parameters are in brackets. ***,**,* indicate statistical significance at 1, 5 and 10 percent level respectively.
Source: Authors' calculations

At first sight, we observe that irrespective of the group country under consideration variables exhibit the same sign while thresholds (in terms of GDP) for AE are almost twice compared to EMD and the whole sample (24% and 13.6% respectively on average). Particularly, we find that an increase in labour productivity leads to a decrease in the SE of 0.048% and 0.049% for the entire group of countries and EMD excluding Kuwait and insignificant in AE. In addition, an additional year of schooling is highly significant and negatively related to the SE in AE, other things being equal. An increase in population growth rate leads to an increase in the SE for the whole sample but not at group level.

In regards to other development indicators, results indicate that SE reversals can be traced onto the two visions: 'exclusion' and 'escape'. For instance, an increase in GDP growth rate below the threshold is negatively related and statistically significant for AE but in EMD (excluding Kuwait) and all countries the effect is positive but significant at 10% level. The explanation for this is straightforward. The 'exclusion' theory explains that market segmentation is a direct consequence of informality, i.e., some workers may be unwilling to abandon formal markets, but others (those with lower skills) instead join the SE when the GDP shrinks. In terms of collections, the 'escape' vision implies a gap of fiscal resources to provide the necessary conditions operate or close a business in formal markets. Conversely, a more robust financial system offset the potential fiscal losses for governments. In the case of EMD countries this would mean a reduction of more than 3.9% of the SE in terms of the GDP. Overall, the divergences between AE and EMD below the optimal threshold suggest that both 'escape' and 'exclusion' operate simultaneously. In line with Perry *et al.* (2007), it is also possible that a macroeconomic level, workers from developing countries may choose SE as a form of 'escape'. In response to Wu and Schneider (2019) findings, we argue that a more robust financial and banking system facilitates the transactions in the formal channels; thus, reducing the incentives for joining the SE provided that household's do not exceed the critical tax revenue threshold. If so, then financial pressure is more intensive, and workers may voluntarily take part-time positions or jobs in units with lower required skills which explains the expansion of the SE[10].

For what concerns the final regime results, panel (b) supports our hypothesis that both perspectives of the SE simultaneously coexist at a macroeconomic level. For instance, an improvement in economy i.e., a higher growth shrinks the SE by 0.130% in EMD and 0.046% in AE. Similarly, the economic cycle dummy follows the same trend as more skills workers may be tempted to join formal markets, although in AE the coefficient is insignificant. Conversely, above the critical threshold level, an increase in labour productivity in AE and EMD would increase the SE by 0.029% and 0.049% respectively with an overall effect of 0.054% for all countries. Interestingly, a higher financial depth implies a higher financial pressure in workers proving the incentives to join the SE in EMD for more than 3.6% while in AE the effect is negative but mostly moderate (-0.338%). Accordingly, above the critical level of collections, financial depth is the main channel and support the inverted u-shape from the stylized facts for which workers choose to join the SE or else remain in the formal economy conditional on business freedom, financial depth and legal origin laws. Accordingly, worker decisions of being formal or informal are not trivial and may have real effects in terms of fiscal resources and the quality of

[10] It is worth stressing that we have not analysed workers satisfaction in regards the type of job, the required skills as well as the educational level. Naturally, these divergences are more likely to be present in surveys irrespective the group of country under consideration.

public services provided by governments. Finally, some omitted variables and endogeneity from different regressors may impact the SE which may lead to a reverse causality issue. In addition, PSTR estimates could be plagued by cross-sectional dependence. In what follows, we address both issues and compare the performance of the PSTR with respect to other estimators.

4.1 Robustness checks

In order to assess the stability of the PSTR results, we considered different estimators for the estimated thresholds in each group. It is a well-known fact that the cross-section covariance of the errors is usually different from zero. Moreover, the unobserved heterogeneity could be related to the presence of endogenous regressors. The empirical literature has addressed these issues using cross-sectional averages or time dummies as additional regressors by identifying common trends that are caused by unobservable factors. In our case, we examined the consistency of the PSTR which (a priori) should not be compromised by above-mentioned problems. Table 5 presents the results for the threshold estimates under several estimators: i) OLS with interactions between endogenous and exogenous variables; ii) Mean-Observation OLS (MO-OLS) of Keane and Neal (2020) and Neal (2016) and iii) Quantile regression for fixed effects (Canay 2011). To save space, we only report the results for the extreme (final regime). As it can be observed, all estimators show a different performance in terms of the unobserved heterogeneity and cross-sectional dependence. For instance, POLS with interactions, time dummies and trend fail to uncover the unobserved heterogeneity. For instance, in AE and labour productivity, GDP growth rate, population growth and government spending are statistically but these lower compared to PSTR point estimates. In EMD, the performance of the POLS is rather poor as financial depth is statistically insignificant and to make things even worse, it accounts less than 10% of PSTR coefficients. In addition, the assumption of normality in one-way or two-way error component models does not hold[11]. Therefore, POLS bias is still related to the unobserved heterogeneity as the null hypothesis of weak against strong CSD is rejected at 1% level. Interestingly, the MO-OLS delivered higher coefficients for labour productivity and financial depth. In EMD, both labour productivity and financial pressure are considerably larger compared to PSTR estimates (0.162 and 9.987 respectively) both of them highly significant above the first levels of collections[12]. This suggests that PSTR did not account the remaining unobserved heterogeneity. Compared to POLS, the CSD statistic of the MO-OLS estimator is lower but still rejected at 1% level for both groups[13]. Finally, we have examined the consistency of the PSTR estimates using the proposed methodology of Canay (2011). Compared to conditional mean models, the median is robust to outliers and may ameliorate

[11] Typically, this can be observed through an excess of kurtosis or skewness in distributions. We have also run some tests for our estimators. Results (available upon request) indicate a leptokurtic and asymmetric distribution of the sample. Therefore, data is not normally distributed and quantile methods are more appropriate to address the unobserved heterogeneity.

[12] The MO-OLS estimator requires a sufficient number of pair of units i.e., individual countries and years to achieve convergence. For those reasons, we restricted the analysis to the first transition levels of revenues in each group: 22.5% in AE and 13% in EMD excluding Kuwait.

[13] According to Keane and Neal (2020) and Neal (2016), the asymptotic properties of the MO-OLS under CSD are still unknown as (individual) regressions are inherently heterogenous. This means that endogeneity needs to be handle with care.

the asymptotic of the estimated coefficients[14]. Results from the last two columns show that the median regression captures the majority of the unobserved heterogeneity. Point estimates are lower compared to PSTR results. In the case of labour productivity and financial depth, both coefficients have the expected signs however none of them are statistically significant. In terms of the unobserved remaining heterogeneity, quantile regressions delivered lower CSD statistics for both groups (10.050 in AE and 5.420 in EMD) although the null hypothesis of weak CSD is still rejected at 1% level. Evidently, there is trade-off between fixed-effects and more granular (individual) trends and interacting latent groups which could be traced to the classical omitted bias problem and/or endogeneity. From our robustness checks, we argue that the use of interactions between strictly exogenous regressors and endogenous variables through quantile methods may tackle both issues at the expense of lower statistical significance levels of coefficients.

Table 5. Shadow economy and tax collections under endogeneity and cross-sectional dependence: (1996-2018)

Variables	POLS (AE)	POLS (EMD$^{\phi}$)	MO-OLS (AE)	MO-OLS (EMD$^{\phi}$)	QREG (AE)	QREG (EMD$^{\phi}$)
Labour productivity growth	0.017*	0.012	0.080**	0.162*	0.014	0.012
	[0.009]	[0.012]	[0.031]	[0.085]	[0.010]	[0.009]
GDP growth rate	-0.082***	-0.071***	-0.146***	-0.218**	-0.095***	-0.080***
	[0.008]	[0.014]	[0.033]	[0.105]	[0.010]	[0.011]
Population growth rate	0.087***	0.023	-0.003	-0.973	0.102***	0.039
	[0.016]	[0.020]	[0.195]	[0.892]	[0.030]	[0.044]
Mean schooling years	0.002	-0.006	-0.165	-0.733*	-0.006	-0.008
	[0.009]	[0.011]	[0.242]	[0.376]	[0.020]	[0.061]
Financial depth (index)	-0.119	0.225	-1.066	9.987*	-0.072	0.090
	[0.080]	[0.199]	[1.435]	[5.296]	[0.088]	[0.137]
Business freedom (score)	0.002*	-0.002			0.001	-0.000
	[0.001]	[0.002]			[0.001]	[0.002]
Government spending (score)	0.002***	0.003***	0.001	-0.015	0.005***	0.002
	[0.001]	[0.001]	[0.004]	[0.010]	[0.001]	[0.004]
Government integrity (score)	0.001	0.001	-0.001	0.004	0.002	0.001
	[0.001]	[0.002]	[0.006]	[0.012]	[0.002]	[0.002]
Economic cycle (dummy)	0.034	0.055	-0.019	0.079	0.015	-0.030
	[0.022]	[0.041]	[0.064]	[0.175]	[0.025]	[0.040]
Financial depth x Legal origin	0.139	-0.128	-0.085	-0.213	0.102	0.253
	[0.119]	[0.214]	[0.115]	[0.922]	[0.196]	[0.504]
Business freedom x Legal origin	-0.001	-0.000			-0.001	0.002
	[0.001]	[0.001]			[0.003]	[0.004]
Time trend	-0.005*	-0.008	0.024	-0.019	-0.006***	-0.008
	[0.003]	[0.005]	[0.064]	[0.121]	[0.002]	[0.007]
Observations	534	699	582	740	534	699
Number of countries	27	37	28	38	32	42
R-squared	0.679	0.319	-	-	-	-
Pseudo R-squared	-	-	-	-	0.120	0.109
F-test (p-value)	(0.000)	(0.000)	-	-	-	-
Wald-test (p-value)	-	-	(0.003)	(0.026)	(0.000)	(0.000)
Threshold (to GDP)	24.0%	13.6%	22.5%	13.0%	24.0%	13.6%
CSD statistic	3.500	19.580	11.950	7.350	10.050	5.420

Note: dependent variable is Shadow economy to GDP (first differences). ϕ Excluding Kuwait (outlier). Robust standard errors in brackets. ***,**,* indicate statistical significance at 1, 5 and 10 percent level respectively.
Source: Authors' calculations

[14] According to Chen and Huo (2021) the assumption of Canay that $N/T^S \to 0$ is not enough to ignore the asymptotic bias of the estimated coefficients as heavy-tailed distributions must be sacrificed. However, given that the focus of this paper is restricted to the median, the coverage rate of the confidence intervals will not suffer from the above-mentioned bias.

5. Concluding remarks and policy implications

5.1 Research implications

This paper examines the effect of SE reversals when government collections are affected to changes in productivity, business regulations and financial depth. To this end, we draw González *et al.* (2005; 2017) Panel Smooth Transition Regression (PSTR) to test two non-mutually exclusive perspectives for employment in the SE: 'exclusion' and 'escape'. Results show that at a macroeconomic level, both perspectives coexist simultaneously. When we break down the analysis by groups, in EMD, the optimal threshold for revenues hovers around 13.6% of GDP while in AE it equals 24%. Thus, institutional tensions lead to SE reversals when financial pressures are binding, i.e., more robust financial and banking system facilitate the transactions in the formal channels while in AE, large reversals are less likely to be observed as countries have a lower tax burden and perceived corruption levels. In this manner, the incentives for joining the SE are lower provided that household's do not exceed the critical tax revenue threshold. Conversely, when economies are above the critical tax level of revenues, then, financial pressure is binding and workers may voluntarily take part-time positions or jobs in units with lower required skills which explains the expansion. Evidently, the institutional has a direct effect over worker's productivity with mixed effects over tax collection. When we assess the validity of the PSTR estimates under endogeneity and cross-sectional dependence, results show that quantile methods outperform linear models (e.g., OLS, MO-OLS) as they account for both endogeneity and cross-sectional dependence. However, the remaining heterogeneity cannot be removed completely as individual trends and latent groups could be at work.

5.2 Policy implications

The findings in this paper presents important implications for the design of labour policies. First, higher financial depth may reinforce worker's incentives to join the formal economy regardless the 'binding' financial point by reducing firm's registration costs. This would enhance accountability as well as the exchange of tax information between governmental agencies. Second, generous tax-incentives programs for low-skill jobs in the formal economy for EMD could deter the incentives to deliberately join the SE. This of course does not imply a self-commitment for entering into formal economy as 'time and freedom' for highly liberal professions (e.g., telemarket) may have a natural comparative advantage of flexibility with respect to traditional jobs. Third, in AE there is not a one-size-fits-all policy as both low and high productivity workers move across formal and informal markets. Evidently, there is a persistent and stable link between job satisfaction acquired in the SE and entrepreneurship. This question is left for future research.

Annex

Table 1. List of countries

Advanced Economies

Australia	France	Latvia	Singapore
Austria	Germany	Lithuania	Slovak Republic
Belgium	Greece	Luxembourg	Slovenia
Canada	Ireland	Malta	Spain
Czech Republic	Israel	Netherlands	Sweden
Denmark	Italy	New Zealand	Switzerland
Estonia	Japan	Norway	United Kingdom
Finland	Korea, Rep	Portugal	United States

Emerging and Developing

Albania	Congo, Rep	India	Pakistan	Tanzania
Azerbaijan	Costa Rica	Indonesia	Paraguay	Thailand
Bangladesh	Cote d'Ivoire	Jordan	Peru	Tunisia
Belarus	Dominican Republic	Kenya	Philippines	Uganda
Botswana	Egypt, Arab Rep	Kuwait	Poland	Ukraine
Bulgaria	Gabon	Malaysia	Saudi Arabia	Uruguay
Cameroon	Ghana	Mali	Senegal	Vietnam
Chile	Guatemala	Mozambique	South Africa	
China	Hungary	Niger	Sri Lanka	

Table 2. Variable definitions and data sources

Variables	Definition	Sources
SE	Shadow Economy (% GDP) (MIMIC Approach)	Elgin et.al (2021)
Tax Revenue	Average revenue (central and general) government excluding grants and social contributions (% GDP)	Government Revenue Dataset (GRD)
GDP	GDP growth rate at PPP in 2020	Total Economy Database
GDP per capita	GDP per capita at PPP in 2020	Total Economy Database
Capital stock	Gross capital formation (% GDP)	World Development Indicators
Population	Growth of population (annual %)	World Development Indicators
Labour productivity	Labour productivity growth per person employed (% change) in 2020	Total Economy Database
Financial depth	Financial institutions depth (index)	International Monetary Fund
Schooling	Mean schooling (years)	Human Development Reports
Business freedom	Business regulations, barriers to start, operate, close (score)	Heritage foundation
Investment freedom	Regulatory restrictions imposed to firms to invest	Heritage foundation
Financial freedom	Banking security and independence from government control (score)	Heritage foundation
Monetary freedom	Price stability, controls (inflation) and distortions market activity (score)	Heritage foundation
Trade freedom	Absence of tariff and non-tariff barriers that affect trade (score)	Heritage foundation
Tax burden	Tax burden (individual and corporate) imposed by government (score)	Heritage foundation
Government spending	Government expenditures, consumption, transfers % GDP (score)	Heritage foundation
Government integrity	Perceived corruption that reduces public trust and economic vitality (score)	Heritage foundation
Property rights	Legal framework (laws) to protect private property (score)	Heritage foundation
Freedom	Economic freedom (score)	Heritage foundation
Cycles	Dummy variable = 1 if the detrended Real GDP is negative, 0 in cc	Author's calculations
Legal commercial codes	Dummy variable = 1 for English, 0 in cc; French =1, 0 in cc; German = 1, 0 in cc and Scandinavian = 1, 0 in cc	Author's calculations based on QoG database

Table 3. Unit root test

Variables	IPS		LLC		PP-Fisher	
	Statistic	p-value	Statistic	p-value	Statistic	p-value
Shadow Economy (% GDP)	1.807	0.965	-0.718	0.237	-2.140	0.984
Total Revenue (% GDP)	-5.892	0.000***	-7.865	0.000***	8.854	0.000***
GDP (PPP) growth rate	-16.528	0.000***	-17.565	0.000***	31.656	0.000***
GDP (PPP) per capita	0.084	0.533	-5.206	0.000***	1.836	0.033**
Capital formation (% GDP)	6.375	0.000***	-7.496	0.000***	6.336	0.000***
Labour productivity growth	-21.314	0.000***	-23.372	0.000***	48.169	0.000***
Financial depth (index)	-2.930	0.002**	-6.318	0.000***	2.474	0.007**
Population growth rate	-6.656	0.000***	-8.281	0.000***	6.851	0.000***
Mean schooling (years)	-2.779	0.003**	-6.423	0.000***	3.757	0.000***
Business freedom (score)	-1.899	0.029**	-4.682	0.000***	0.995	0.160
Financial freedom (score)	-4.306	0.000***	-5.902	0.000***	7.008	0.000***
Investment freedom (score)	-3.087	0.000**	-4.906	0.000**	5.472	0.000**
Monetary freedom (score)	-11.569	0.000***	-13.781	0.000***	20.847	0.000***
Trade freedom (score)	-8.512	0.000***	-9.854	0.000***	16.504	0.000***
Tax burden (score)	-5.698	0.000***	-8.614	0.000***	11.850	0.000***
Government spending (score)	-8.079	0.000***	-9.052	0.000***	12.315	0.000***
Government integrity (score)	-12.834	0.000***	-13.620	0.000***	24.925	0.000***
Property rights (score)	-3.683	0.000***	-6.509	0.000***	5.443	0.000***
Economic freedom (score)	-4.068	0.000***	-7.193	0.000***	5.703	0.000***

Note: three (second generation) tests are applied to determine whether the variables in the model contain a unit root; these are: (i) the IPS test (Im *et al.* 2003); (ii) the LLC test (Levin *et al.* 2002) and (iii) the PP-Fisher inverse Chi-square test (Phillips and Perron 1988). All variables are demeaned to account for cross-sectional dependence. ***,**,* indicate statistical significance at 1, 5 and 10 percent level of significance, respectively.
Source: Authors' calculations

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INAPP
ISTITUTO NAZIONALE PER L'ANALISI
DELLE POLITICHE PUBBLICHE