GROWING APART OR MOVING TOGETHER? SYNCHRONIZATION OF INFORMAL AND FORMAL ECONOMY CYCLES

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Growing Apart or Moving Together?
Synchronization of Informal and Formal Economy Cycles

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Abstract: We study the degree of synchronization between formal- and informal-economy business cycles. Using a comprehensive database of informal activity that covers a wide range of informality measures from almost 160 countries over the 1990-2018 period, we report two major results. First, fluctuations in informal-sector output are strongly positively correlated with those in formal-sector output. In contrast, fluctuations in informal employment are largely uncorrelated with those in formal-sector output. Second, movements in the formal economy tend to spillover to the informal economy. Using a novel set of instrumental variables, we show that fluctuations in formal-sector output "cause" movements in informal-sector output.

Key Words: Informal economy, self-employment, business cycle.
JEL Codes: E26, E32, J46, O17

1. Introduction

In an average emerging market and developing economy (EMDE), the informal sector accounts for about one third of GDP, compared with about 18 percent of GDP in advanced economies (Figure 1). Its large size makes the informal economy a potential amplifier or dampener of business cycles that policy makers need to take into account when formulating policies. If the informal economy expands while the formal economy contracts, it may support household incomes and consumer demand during economic downturns and serve as a safety net (Loayza and Rigolini 2011). If the informal economy behaves procyclically (that is, grows during expansions in the formal economy), it could function as an auxiliary "growth engine" during economic expansions (Chen 2005; Dell'Anno 2008; Meagher 2013).

In theory, the cyclical relationship between informal and formal sectors is ambiguous.[2] Some theoretical models have shown that the informal economy may absorb a larger share of workers as jobs become scarce in the formal sector during economic downturns (Bosch, Goni and Maloney 2007; Dix-Carneiro et al. 2021; Loayza and Rigolini 2011). Such behavior by the informal sector could facilitate economic recovery—by providing a potential supply of labor to the formal sector and preventing the hysteresis costs of unemployment—if re-entry into the formal sector is possible when the formal economy returns to expansion (Colombo, Onnis, and Tirelli 2016; IMF 2017). In contrast, if informal firms provide services as well as final and intermediate goods to the formal sector, formal and informal sectors move in tandem. In addition, informal-economy income can support formal-economy demand. In these circumstances, the informal economy would amplify macroeconomic fluctuations.[3]

Empirical evidence on the behavior of the informal economy over the business cycle is also inconclusive. This has been attributed partly to different country characteristics and the roles of different economic shocks. After presenting a brief review of the literature on the cyclical behavior of the informal economy, we analyze the cyclical relationships between formal and informal sectors using multiple measures of informality for a large number of countries. In addition to studying the extent of synchronization between formal and informal economies, here we also investigate whether fluctuations in formal economy output "cause" fluctuations in output or employment in the informal economy via an instrumental variable approach.

Our paper makes three contributions to the literature. First, it is the first comprehensive analysis of the cyclical linkages between formal and informal sectors using multiple measures of informality for a large set of economies—about 160 economies, comprising 36 advanced economies (AEs) and about 120 emerging markets and developing economies

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[2] Some early research suggested that the degree of cyclicality of the informal economy depends on the measure of informality used and country characteristics.

[3] For cyclical linkages between the formal sector and informal sector, see Arvin-Rad et al. (2010), Docquier, Muller, and Naval (2017), Gibson (2005), Lubell (1991), Restrepo-Echavarria (2014), Roca, Moreno, and Sanchez (2001), and Schneider (1998).

(EMDEs). It covers a long, recent period—1990-2018—and is the first study of the behavior of both output and employment in the informal economy as previous studies have focused on either one of these two variables. The comparison yields valuable insights into the cyclicality of labor productivity.

Second, we focus on the absolute size of the informal economy, while earlier studies examined the informal economy only in relation to the formal economy. This allows for a more precise understanding of cyclical dynamics. Specifically, earlier studies examined the size of the informal economy relative to that of the formal economy without explaining the underlying mechanism. For instance, when the relative size of the informal sector rises during recessions, it could reflect an expanding informal economy or an informal economy that shrinks less than the formal economy. Some previous studies have interpreted the rising ratio as evidence for an expanding informal economy during recessions. A few previous studies of the procyclicality of informal output levels have been restricted to a small group of countries and either study solely output (Bajada 2003; Dell'Anno 2008; Giles 1997) or solely employment (Fiess, Fugazza, and Maloney 2010).

Third, our paper is the first to document a causal link from formal-economy cyclical developments to the informal economy by using an instrumental variables approach. This improves on existing studies that have tested for basic Granger causality between formal and informal economy within individual countries. The previous Granger causality tests help to determine whether one time-series is useful in forecasting another. However, they do not test for "true" causality as instrumental-variable regressions are able to identify (Angrist and Pischke 2009), since omitted variables can generate spurious causality (Eichler 2009).

We report two major results. First, we find that informal-economy output moves in step with formal output: informal-economy output movements are strongly positively correlated with formal-economy output movements. Hence, when earlier studies found that the share of the informal economy rose during formal-economy recessions, this reflected a slower absolute decline in informal than formal output rather than an absolute increase in informal activity. In addition, we find that informal employment largely behaves "acyclically."

Second, in an instrumental variable estimation, we show that the direction of causality runs from the formal economy to the informal economy. Specifically, our paper documents a causal link from fluctuations in formal-economy output to fluctuations in informal-economy output. In terms of employment, such a causal link is not found: whereas informal output behaves procyclically, informal employment behaves acyclically. The latter may indicate that informal labor markets do not adjust in terms of employment status during economic cycles but in terms of wages or working hours (Guriev, Speciale, and Tuccio 2016; Meghir, Narita, and Robin 2015).

The rest of the paper is organized as follows. Section 2 summarizes past studies of the comovement between formal and informal business cycles, followed by Section 3 on the data and methodologies employed in the paper. Section 4 then presents evidence on the

comovement of formal and informal economies. Section 5 further provides new estimates of the causal relationship between formal and informal economy business cycles and discusses potential explanations for the cyclical behavior of the informal economy. Finally, Section 6 concludes with a discussion of policy implications and directions for future research.

2. Literature review: Linkages between formal and informal sectors

The literature on the cyclical behavior of the informal economy offers mixed conclusions. Studies focusing on the share of the informal economy in total output or employment tend to find countercyclical behavior whereas studies focusing on output or employment levels tend to find procyclical behavior. The theoretical literature suggests that the nature and degree of cyclicality, mainly in the share of employment informality, depends on the type of shocks causing business cycle fluctuations and on the presence of labor market rigidities. This section summarizes this literature.[4]

2.1 Informal economy as a countercyclical safety net

The informal sector can serve as a buffer and safety net for the poor if it absorbs labor during recessions. This can facilitate an economic recovery provided that re-entry into the formal sector is possible when the formal economy returns to expansion (Colombo, Onnis, and Tirelli 2016; IMF 2017; Loayza and Rigolini 2011).

Macroeconomic evidence. Studies that employ macro data suggest the informal economy can behave "countercyclically" in the sense that the share of informal employment rises during business cycle downturns. For example, one study reported that on average in 54 economies during 1984-2008, a one-standard-deviation slowdown in GDP per capita growth (that is a slowdown of 3 percentage points a year) was associated with a short-run increase in the share of self-employment in the total labor force by 1.2 percentage points, although with considerable cross-country heterogeneity (Loayza and Rigolini 2011).

In one study, the correlation between informal employment and official GDP has been estimated as modestly negative (about -0.3), whereas the correlation between formal employment and formal output was strongly positive (Fernández and Meza 2015). A study that used electricity consumption as a proxy for total economic activity found that the informal economy expanded following banking crises in 48 economies over the 1984-2005 period (Colombo, Onnis, and Tirelli 2016). Several studies have found that during economic downturns, the share of informal output tended to increase (Busato and Chiarini 2004; Elgin 2012; Kaufmann and Kaliberda 1996).

More procyclical fiscal policy in less developed economies with weaker institutions may contribute to the counter-cyclicality of informal activity. Fiscal policy tends to be more procyclical in countries with higher informality (Çiçek and Elgin 2011). In particular,

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[4] Several recent studies argue that pervasive informality may influence the measured cyclicality of the formal economy. For example, models with a large and poorly measured informal sector can generate excess volatility of formal consumption relative to formal output—a common feature of business cycles in many EMDEs (Horvath 2018; Restrepo-Echavarria 2014).

procyclical fiscal consolidation during recessions, including through higher taxes, may encourage more informal employment and output.

Microeconomic evidence. Work-flow data for Brazilian metropolitan labor markets between 1983 and 2002 showed that the informal sector was able to absorb more labor during economic downturns as jobs became scarcer in the formal sector (Bosch, Goni, and Maloney 2007). The share of formal employment fell as formal-economy output contracted, in part because the rate at which workers found formal jobs plummeted while the rate at which they found informal jobs remained broadly stable (Bosch and Esteban-Pretel 2012).

2.2 Informal economy as a "procyclical engine" of growth

Since informal firms provide services, as well as final and intermediate goods to the formal sector, a positive correlation between formal and informal sector activity may emerge. In addition, informal-economy income can support formal-economy demand.[5]

Macroeconomic evidence. In studies focusing on absolute output levels rather than the share of the informal economy, movements in informal-economy output have been found to be positively correlated with movements in formal-economy output in Australia, New Zealand, Canada, and a group of 19 Latin American economies (Bajada 2003; Dell'Anno 2008; Giles 1997; Tedds and Giles 2000). In a group of developing countries, episodes where relative demand or productivity shocks expanded the nontradables sector (as opposed to the tradables sector) were associated with higher informal employment shares (hence, pro-cyclicality; Fiess, Fugazza, and Maloney 2010). In Brazil and Mexico, higher separation rates from informal jobs and a large drop of the formal job finding rate may induce labor outflows from the informal sector during recessions (Bosch and Maloney 2008). A theoretical model establishes procyclical informal-formal sector linkages when formal firms sub-contract labor-intensive stages of production to the informal sector (Arvin-Rad, Basu, and Willumsen 2010).

Microeconomic evidence. In firm-level data for India, formal and informal sector employment have been found to be positively correlated, in part because subcontracting by formal-sector firms to informal firms contributes to job creation in the informal sector (Moreno-Monroy, Pieters, and Erumban 2014).[6] An examination of data from Indian manufacturing firms showed that the gross value added of several predominantly informal industries was positively correlated with that of the formal sector as well as with foreign

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[5] For linkages between the two sectors, see Arvin-Rad, Basu, and Willumsen (2010), Lubell (1991), and Moreno-Monroy, Pieters, and Erumban (2014). For linkages focusing on income support, see Docquier, Müller, and Naval (2017), Eilat and Zinnes (2002), Gibson (2005), Kanbur (2017), Schneider (1998), and World Bank (2014). Although the relationship between formal and informal sectors may be symbiotic in the short run, in the long-run pervasive informality may create poverty traps and stymie economic development.

[6] In an earlier study focusing on two European countries, it was found that at least two-thirds of the income earned in the informal economy was immediately spent in the formal economy, providing a considerable stimulus for it (Schneider 1998).

direct investment (FDI). This may be indicative of technological spillovers to both formal and informal sectors (Beladi, Dutta, and Kar 2016).

2.3 Factors influencing the cyclicality of the informal economy

Some studies have sought to reconcile the mixed evidence by pointing to country characteristics that would generate different degrees of procyclicality. Others have pointed to different kinds of shocks that would lead to different types of cyclical linkages.

Cross-country heterogeneity. There is considerable cross-country heterogeneity in the degree of pro-cyclicality of informal employment. It has been found to be higher when informality was greater (Loayza and Rigolini 2011), when informal employment was more common (Shapiro 2014), or when there were stronger informal-formal sector linkages such as through subcontracting (Mbaye, Benjamin, and Gueye 2017; Moreno-Monroy, Pieters, and Erumban 2014).

Sources of shocks causing business cycles. The informal economy can move procyclically or countercyclically, depending on the sectoral origin of the shocks that generate business cycles in the presence of wage rigidities, especially in the formal sector (Fiess, Fugazza, and Maloney 2010; Leyva and Urrutia 2020). Positive relative demand or productivity shocks to the non-tradable sector, especially services, where the share of informal employment tends to be higher could increase informal employment, generating procyclicality in informal employment, especially when combined with wage rigidities in the formal sector.[7] Conversely, in the presence of wage rigidities, a negative shock to the tradable sector would expand informal (non-tradables) employment and thus appear as countercyclical.

3. Data and methodology[8]

The empirical analysis here relies on the database of measures for informality developed in Elgin et al. (2021). It applies a battery of statistical tests to establish, first, comovement between formal output and measures of informal activity and, second, to analyze the direction of causality.

3.1 Data: informality measures

Two model-based estimates stand out in their country-year coverage and movement over time and, hence, make them more suitable for business cycle analyses than other estimates on informal economic output (Elgin et al. 2021). These two types of model-based estimates are the multiple indicators multiple causes (MIMIC) estimates (based on Schneider, Buehn, and Montenegro 2010) and the dynamic general equilibrium (DGE) estimates (Elgin et al. 2021). Hence, we focus on the MIMIC estimates and the DGE estimates.[9]

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[7] See Ohnsorge, Okawa, and Yu (2021) for a discussion about sectoral distribution in the informal economy. Informality tends to be higher in labor-intensive service sectors, which are largely non-tradable.

[8] See Table A.1 for a summary of descriptive statistics on all variables used here.

[9] The correlation of the DGE measure does not occur by construction (see Annex A for details).

The MIMIC model is a structural equations models that can be applied to estimate the size of informal economic activity. Elgin et al. (2021) replicate the most cited MIMIC study, Schneider, Buehn, and Montenegro (2010), to estimate the share of informal output in percent of official GDP. Both economic and institutional indicators are used in the MIMIC model. The resulting estimates are available annually for 160 countries (including 36 AEs) over the period 1993-2018.

The DGE model estimated in Elgin et al. (2021) considers how households allocate labor between formal and informal economies within each period and how the allocation changes over time. In comparison to other methods, the DGE approach stands out in its comprehensive country-year coverage, transparent economic reasoning, and its applicability in policy experiments and projection (Loayza 2016). Annual DGE estimates are available for 158 economies (including 36 AEs) for 1990-2018.

These measures of informal output are complemented with self-employment as a proxy indicator of informal employment (La Porta and Shleifer 2014). Annual data on shares of self-employment are available for 179 economies (including 36 AEs) between 1990 and 2018.

All measures of informal activity are defined in levels of output or levels of employment, rather than as shares of total activity or employment as is standard practice in the business cycle literature (for example, Claessens, Kose, and Terrones 2012; Fernández and Meza 2015). Data for formal output are from the Penn World Table 9.1 and the World Development Indicators (WDI) (in 2011 U.S. dollars; data from Penn World Table 9.1 were expanded using WDI) (see Table A.1 for details). The Hodrick-Prescott (HP) filter is used to detrend the time series with the smoothing parameter set to 100. All exercises rely on detrended logarithms of these levels. The findings are robust to using annual growth of formal and informal output and employment or to using the Baxter-King filter to detrend series.

3.2 Empirical methodology

Comovement. To quantify the comovement of formal output with the various measures of informality, we employ a wide range of measures, including correlation, factor models, coincidence of turning points and business cycle phases, and probit and linear regression models (Claessens, Kose, and Terrones 2012; Kose, Prasad, and Terrones 2003; Restrepo-Echevarria 2014). The methodological details are discussed below.

First, we follow Restrepo-Echevarria (2014) in computing the lag and contemporaneous correlations of official GDP and output (and employment) in the informal sector. These basic correlations illustrate whether the formal and informal economies are moving together and whether the formal economy is leading the informal economy. Since employment may move differently from economic output, we also include formal employment in our analysis. The results are summarized in Table 1.

Then, we apply an alternative method of estimating business cycles comovement, which is a dynamic factor model (Kose, Prasad, and Terrones 2003). The model decomposes the

fluctuations in formal and informal economies into a dynamic common factor and an idiosyncratic factor. If the dynamic common factor can explain a large portion of the variance in formal and informal economic output (employment), the degree of comovement between formal and informal business cycles is high. Specifically, the dynamic common factor model has the following form (Stock and Watson 2011): [10]

$$Y_t = \beta f_t + \varepsilon_t; f_t = \emptyset(L)f_{t-1} + \mu_t$$

where Y_t is a vector of variables that contains official GDP, DGE-based and MIMIC-based informal output estimates, formal employment, and informal employment. f_t is the dynamic common factor, which follows an AR (1) process. ε_t and μ_t are error terms (i.d.d.). The dynamic common factor model is estimated for each country in our sample with sample statistics reported in Table 2.

To illustrate the synchronization between informal and formal-economy business cycles, we compute the coincidence of formal and informal business cycle phases, which are identified as follows. First, Bry and Boschan (1971)'s algorithm is applied to identify the turning points of business cycles (i.e. peaks and troughs), using the procedure of Harding and Pagan (2012). For annual data, we define peaks (troughs) as occurring at time t whenever output (employment) growth is positive (negative) in t but negative (positive) in t+1 (Berge and Jorda 2011).[11] Second, we classify business cycle phases as defined in Claessens et al. (2012). Using the turning points identified in the first step, recessions are the periods from peak to trough while expansions are the periods from trough to peak. The coincidence of these phases is shown in Table 3 (as a robustness check, we also report the coincidence of these turning points in Table A.2).

Lastly, some regression models are used to understand the comovement of formal output with the various measures of informality. Using the business cycle phases and turning points identified above, a probit regression model is estimated to examine whether the probability of the informal economy being in (or starting) a recession increases when the formal economy is in a recession. The probit model has the following form:

$$Pr\left(ISREC_{it} = 1\right) = \phi(\alpha + \beta FS_{it} + \theta X_{it} + \pi_i + \mu_t + \epsilon_{it}),$$

where $ISREC_{it}$ is a dummy variable that equals one when the informal sector in country i and year t is in recession, and zero otherwise.[12] FS_{it} is a dummy representing recession in the formal economy, and X_{it} is a vector of control variables. Following Elgin and Oztunali (2012 and 2014), X_{it} includes the annual growth rates of real investment and domestic credit to the private sector. These control variables are included as they

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[10] Robustness tests for longer lags indicate that the coefficients for additional lags of the common factor are insignificant. All data series are detrended and standardized before estimation. Additional results are available upon request.

[11] A censoring rule imposes that, in the event of multiple peaks (troughs) within a five-year window around a peak (trough), the highest (lowest) peak (trough) is picked.

[12] For the probit model on the start of informal recessions, $ISREC_{it}$ is a dummy variable that equals one when the informal sector in country i and year t is in the start of a recession, and zero otherwise.

influence the fluctuations in both formal and informal economies (for instance, Ferreira-Tiyaki, 2008; Elgin and Oztunali, 2014; La Porta and Shleifer 2014). Data for investment are provided by PWT 9.1, updated with data from World Development Indicators (WDI 2020), and credit data are obtained from WDI. All regressions include country dummies (π_i) and year dummies (μ_t) to control for macro trends across countries in a certain year and factors that are country specific.

"Casual" relationship. As a second step, we use an instrumental variable two-stage least squares (IV-2SLS) approach to estimate the direction of causality between formal output and measures of informal activity. We consider instrumental variables that affect formal-economy output but do not directly influence informal-economy output: movements in trade-related variables and changes in government consumption. Being concentrated in the non-tradable sector (Fiess, Fugazza, and Maloney 2010), the informal economy is unlikely to be influenced by movements in trade-related variables directly. In addition, government consumption includes all government current expenditures for purchases of goods and services (including compensation of employees), without covering transfers such as social benefits and subsidies. Governments are typically restricted, by legislation and regulation, from purchasing goods and services directly from the informal economy. As governments purchase goods and services from the formal economy, changes in government consumption lead to fluctuations in the formal economy without affecting the informal economy directly. Therefore, movements in trade-related variables and changes in government consumption can be interpreted as exogenous instruments that directly affect the formal economy without directly influencing the informal economy.

Data on movements in trade-related variables and changes in government consumption are obtained from WDI (2020). Trade-related variables include terms of trade and exports of goods and services (at constant 2010 U.S. dollars). Government consumption captures general government final consumption expenditure (at constant 2010 U.S. dollars). These measures—as well as all the output and employment measures—are transformed into cyclical components as deviations from the Hodrick-Prescott-filtered trend with a smoothing parameter of 100. To further make sure that the causal direction only runs from the formal economy to the informal economy, cyclical movements in formal GDP are lagged in the following regressions.[13]

The IV-2SLS regression model has the following form:

$$FS_{it-1} = \alpha_1 + IV_{it-1} + \boldsymbol{\theta X_{it}} + \pi_i + \mu_t + \epsilon_{it} \qquad\qquad \textit{(1}^{st}\textit{ Stage)}$$

$$IS_{it} = \alpha_0 + \beta \widehat{FS_{it-1}} + \boldsymbol{\theta X_{it}} + \pi_i + \mu_t + \epsilon_{it} \qquad\qquad \textit{(2}^{nd}\textit{ Stage)}$$

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[13] The results are robust to using annual growth rates of these variables. They are also robust when cyclical movements in formal GDP are not lagged. They are available upon request.

In the first stage, the lagged cyclical component of formal-economy output (FS_{it-1}) is the dependent variable, while the lagged trade-related variables and government consumption in country i (IV_{it-1}) are the explanatory variables.[14] The regression results of the first stage are used to obtain the estimated cyclical component of formal economy output $\widehat{FS_{it-1}}$, which is included as the explanatory variable in the 2nd stage. $\widehat{FS_{it-1}}$ is used to explain the cyclical components of informal-economy output or informal employment (IS_{it}) in year t. The coefficient estimates β measures the magnitude and direction of the impact of fluctuations in the formal business cycle on the informal economy. In both stages, a vector of control variables ($\boldsymbol{X_{it}}$), country fixed effects (π_i) and year fixed effects (μ_t) are controlled for. The vector of control variables ($\boldsymbol{X_{it}}$) are the same as in the probit model, which includes the growth rates of domestic credit to the private sector and real investment (see Table A.1 for detailed variable descriptions).

4. Synchronization of formal and informal economy cycles

A battery of statistical exercises suggests that informal output is strongly positively correlated with formal output, hence behaves in a procyclical manner. In contrast, informal employment is largely unrelated to formal output movements, hence behaves in an acyclical manner.

Correlations. Contemporaneously, informal-economy output movements are highly and statistically significantly correlated with formal-economy output movements (Table 1). Formal employment is also positively and statistically significantly correlated with formal-economy output, although considerably less strongly, particularly in EMDEs, whereas informal employment is largely uncorrelated with formal-economy output, again particularly in EMDEs. Lag correlations are considerably smaller than contemporaneous correlations, suggesting that informal output responds to formal-economy output fluctuations within a year.[15]

Common factor approach. For each country, a common factor is extracted from informal- and formal-sector output as well as informal and formal employment, in a dynamic factor model as depicted in section 3.2. The results are broadly in line with the correlations discussed above. On average, the common factor explains about 40 percent of the variance in both formal-economy output and DGE-based informal-economy output (Table 2). It explains somewhat less (24 percent) of the variance in MIMIC-based informal-economy output, in part because MIMIC estimates tend to be more stable than DGE estimates as a result of the reliance of the former measure on slow-moving country characteristics such as economic and business freedom indices. The common factor also explains a modest fraction of movements in formal employment, especially in advanced economies. In contrast, informal employment does not appear to share a common factor with formal

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[14] Results are similar when annual growth rates are used instead of cyclical deviations from trend. Results are available upon request.

[15] In EMDEs, however, lag correlations are statistically indistinguishable from contemporaneous correlations.

employment or with informal or formal-economy output in either advanced economies or EMDEs.

Coherence in business cycle phases and turning points. Formal- and informal-sectors typically share the same business cycle phases (Table 3). In more than 90 percent of country-year pairs, formal and informal output are in the same business cycle phase. This coincidence of business cycle phases is considerably less pronounced for employment than for output. Formal employment and formal output share the same business cycle phases in 75 percent of all country-year pairs, while informal employment is in the same phase as formal output in 54 percent of country-year pairs. Similarly, between 30 and 70 percent (using MIMIC or DGE, respectively) of turning points (peak or trough) of formal output business cycles coincide with turning points of informal output business cycles, whereas informal employment turning points coincide about 10 percent of the time with formal-economy output turning points (see Table A.2 for details).

Econometric approaches. A probit regression is used to estimate the probability of the informal economy being in recession at the same time as the formal economy is. Indeed, the probability of informal output being in recession is statistically significantly higher when formal output is in a recession, even after controlling for country and year fixed effects as well as investment and credit growth (Table A.3). On average, the probability of informal output being in recession is higher by about 25 percentage points when formal output is in recession than when formal output is not in recession.[16] Similar results pertain to the probability of a new recession starting in the informal sector when the formal economy is in recession (Table A.4). Again, this contrasts with the finding that the probability of informal employment declining is little affected by a formal-economy contraction.

5. Causal linkages between formal- and informal-economy cycles

The results described in the previous section suggest a strong correlation between formal and informal economies. Some previous studies reported strong evidence of Granger causality running from the formal economy to the informal economy in individual countries, and mild evidence of reverse causality in some cases (Bajada 2003; Giles 1997; Giles, Tedds, and Werkneh 2002). However, Granger causality does not establish "true" causality and ignoring reverse causality could lead to biased estimation results (Angrist and Pischke 2009). Hence, here we employ a novel approach with an instrumental variables estimation to test for the direction of causality. The results based on this approach suggest that formal economy output fluctuations "truly" cause informal-economy output fluctuations.

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[16] Probabilities for the global sample need not to be near the average of the advanced economy and EMDE sample because of different year fixed effects.

5.1 Baseline results

In the baseline model, formal-economy output is instrumented using government spending and two trade-related variables: the cyclical components of the terms of trade and real exports. Being largely concentrated in the non-tradable sector, the informal economy is unlikely to be highly influenced directly by movements in trade-related variables. In addition, government spending is typically restricted, by legislation and regulation, from purchasing goods and services from the informal economy. Therefore, movements in trade-related variables and changes in government consumption can be interpreted as exogenous instruments that directly affect the formal economy without directly influencing the informal economy.

The baseline results shown in Table 4 confirm that formal-economy output fluctuations in the previous year, as instrumented by lagged trade-related terms and government consumption, "cause" fluctuations in the informal economy in the following year. On average, a 1 percent increase in formal-economy output "causes" a 0.4-0.8 percent expansion in the following year in informal-economy output and formal employment. This impact does not differ materially between advanced economies and EMDEs. In contrast, such formal-economy output fluctuations do not cause significant fluctuations in informal employment, especially in EMDEs (Table 4).

5.2. Robustness exercises

We conduct several robustness exercises. First, we check the robustness of the baseline results to alternative model specifications by instrumenting only with either trade-related variables or government consumption. Second, we use system GMM (Generalized Methods of Moments) to address potential endogeneity bias. Third, we use an alternative variant of the DGE measures to test for robustness to different modelling assumptions in the construction of the DGE estimates. Lastly, we repeat our exercise for shares of the informal economy in output and employment to ensure consistency with previous estimates in the literature.

Different sets of instrumental variables. To remove the potential endogeneity of government consumption in the case of MIMIC, we estimate results using trade-related instrumental variables (terms of trade and export growth) only (Table 5). The estimated impact of lagged formal-economy output fluctuations on informal-economy output and for formal employment is (statistically) in line with the estimated impact shown in Table 4. Specifically, a 1 percent increase in formal-economy output (statistically significantly) in year *t-1* again raises informal-economy output by 0.4-0.9 percent in year *t*, depending on the informal-economy output measure chosen. The effect is somewhat larger in advanced economies than in EMDEs. Again, there is no significant impact on informal employment, either in EMDEs or in advanced economies.[17] Similar results are found when using changes in government consumption alone as instruments (See Table A.5).

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[17] The Kleibergen-Paap rk LM statistic and the Cragg-Donald Wald F statistic suggest that the instruments are strong instruments.

Endogeneity bias (system GMM). As an alternative way to address endogeneity bias, we apply system GMM to estimate the impact of official GDP on informal output, formal employment and informal employment. The results are strongly in line with baseline findings. As shown in Table 6, a 1 percent rise in formal economy output significantly increases output in the informal sector in the following year by 0.4-0.8 percent but no significant response from informal employment (similar results were found in Table A.6 when using a fixed-effect model).

Alternative DGE estimates. DGE estimates of informal output in part depend on benchmark estimates and assumptions about productivity growth in the informal economy (Elgin et al., 2021). We test for the robustness of our results to these assumptions by using another set of DGE estimates that are calibrated using a series of survey-based self-employment data (see Annex B for calibration details). This approach also avoids the assumption that informal productivity growth is the weighted average of formal-economy capital and productivity growth. Thus, this estimation approach weakens the link between informal and formal output due to the model assumptions in Elgin and Oztunali (2012). Table 7 confirms the baseline findings that fluctuations in formal-economy output cause informal output to move in the same direction and almost the same magnitude. On average, informal output expands significantly by 0.5-0.8 percent, especially in EMDEs, when formal-economy output rises by 1 percent in the previous year. While the results are less significant when government consumption is the only instrumental variable, the results are largely robust across different sets of instrumental variables.

Shares of the informal economy. Here we redo the exercises in Tables 1, 4 and 5 using the *share* of informal output (in percent of official GDP) and the *share* of formal and informal employment (in percent of total employment).[18] These robustness checks ensure the consistency between our findings and previous estimates in the literature (e.g. Loayza and Rigolini 2011). As expected, both shares of informal output and shares of informal employment are found to be significantly negatively correlated with formal-economy output (except in advanced economies when using DGE estimates), while shares of formal employment are positively correlated (Table A.7). The regression results show that the share of informal output contracts significantly by 0.1-0.4 percentage points of GDP, on average, when formal-economy output expands by 1 percent in the previous year (Tables A.8 and A.9).

5.3 Explaining the cyclicality of the informal sector

The previous sections have established that informal-economy output and formal employment behave "procyclically," in the sense of responding to formal-economy output fluctuations significantly and positively. Meanwhile, informal employment acts "acyclically" in the sense of not significantly and systematically responding to formal-economy output fluctuations. This accounts for the rising share of informal employment

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[18] All shares of informal output and shares of formal and informal employment are in logs and Hodrick-Prescott-filtered, as in Table 4. When shares are not logged but Hodrick-Prescott-filtered, the results remain the same and will be provided upon request.

during formal-economy recessions documented by studies like Loayza and Rigolini (2011).[19]

There are at least wo possible reasons explaining why informal employment behaves acyclically. First, informal employment may respond to different shocks from informal output and formal employment, or it may respond differently to the same shocks. As an example of the latter, the informal labor market, being more flexible than the formal sector, may respond by reducing hours worked per person or by lowering wages, rather than by reducing the number of employed.[20] A second possible reason is that while job separation rates rise during recessions in both formal and informal sectors, the rate at which workers find formal jobs plummets while that at which they find informal jobs remains broadly stable (Bosch and Esteban-Pretel 2012; Bosch, Goni, and Maloney 2007).

6. Conclusions

Our paper presents a wide variety of approaches that document the strong comovement of informal-economy output with formal-economy output, caused by movements in formal output, but the lack of such comovement for informal employment. This suggests that although output in the informal economy behaves procyclically and, therefore, may amplify aggregate output fluctuations, the unresponsiveness of informal employment to the business cycle may provide a buffer for household incomes by ensuring continuity of employment in the informal economy (Ferreira-Tiryaki 2008; Roca, Moreno, and Sánchez 2001).

The resilience of informal employment in the face of business cycle swings, juxtaposed with the weaker development levels associated with informality (Ohnsorge, Okawa, and Yu 2021), suggests a trade-off. In the short run, informal employment can provide a safety net during business cycles; in the long term, however, the informal sector can exacerbate poverty and stymie development (Docquier, Müller, and Naval 2017). Policy measures that—deliberately or inadvertently—reduce informality and thus benefit longer-term development and poverty reduction could, therefore, usefully be accompanied by a strengthening of official social safety nets to protect vulnerable population groups from the short-term costs of the loss of the unofficial safety net provided by the informal sector. The necessity of strengthening the resilience of the informal sector is particularly relevant in the context of the COVID-19-induced recession (Ohnsorge and Yu 2021). If comovement between formal and informal output reflects synergies, such as through subcontracting, policy measures aimed at curtailing informal activity could disrupt formal activity. These effects could be mitigated if measures that reduce informality were accompanied by greater labor and product market flexibility in the formal sector that facilitates the absorption of informal-sector participants (World Bank 2019).

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[19] Similarly, it was shown that foreign interest rates are inversely and significantly related to formal job creation but insignificantly related to informal job creation and destruction, resulting in the counter-cyclicality of the share of informal employment (Leyva and Urrutia 2020).

[20] For discussions of these arguments, see Guriev, Speciale, and Tuccio (2016), Loayza and Rigolini (2011), Maloney (2004), and Meghir, Narita, and Robin (2015).

The results reported in this paper point to several promising areas for future research. First, the cyclical behavior of other features of the informal economy could usefully be examined. For example, if greater flexibility of wages or hours worked is what ensures acyclical behavior of informal employment despite procyclical informal output, then informal wages or hours of employment should be particularly procyclical. It would be useful to establish whether this is the case. Second, the channels through which formal-economy business cycles affect the informal economy could be further explored and quantified. This includes the degree of interconnectedness between formal and informal firms.

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Annex A. Theoretical proof for whether the procyclicality of the DGE estimates is by construction

The official GDP has the following form:

$$Y_{Ft} = A_{Ft} K_t^\alpha N_{Ft}^{1-\alpha}$$

where Y_{Ft} is the output in the formal sector in year t, A_{Ft} is the productivity in the formal sector, K_t is the capital stock available in year t, and N_{Ft} is the employment in the formal sector in year t.

The production function for informal output is assumed to have the following form:

$$Y_{It} = A_{It} N_{It}^\gamma.$$

where Y_{It} is the output in the informal sector in year t, A_{It} is the productivity in the informal sector, and N_{It} is the employment in the informal sector. As assumed in Elgin and Oztunali (2012). $\dot{A}_{It} = \frac{1}{2}(\dot{K}_t + \dot{A}_{Ft})$ and N_{It} is a function of A_{Ft} and K_t. To simplify the discussion, it is assumed that $A_{It} = \frac{1}{2}(A_{Ft} + K_t) + c$, where c is a constant. N_{It} has the following form: [21]

$$N_{It} = \left\{ \frac{\gamma A_{It}}{(1-\tau_t)(1-\alpha)A_{Ft}} \left[\frac{\frac{1}{\beta}-1+\delta}{\alpha(1-\tau_t)A_{Ft}} \right]^{\frac{\alpha}{1-\alpha}} \right\}^{\frac{1}{1-\gamma}}.$$

Since A_{It} and N_{It} are functions of A_{Ft} and K_t, Y_{It} can be expressed as a function of A_{Ft} and K_t.we know that the comovement between Y_{It} and Y_{Ft} can be only driven by shocks in A_{Ft} and K_t. [22] Since $\frac{\partial Y_{Ft}}{\partial K_t} > 0$ and $\frac{\partial Y_{Ft}}{\partial A_{Ft}} > 0$, the positive correlation between Y_{Ft} and Y_{It} could be driven by construction if $\frac{\partial Y_{It}}{\partial A_{Ft}} > 0$ and $\frac{\partial Y_{It}}{\partial K_t} > 0$. Therefore, the values of $\frac{\partial Y_{It}}{\partial A_{Ft}}$ and $\frac{\partial Y_{It}}{\partial K_t}$ will be discussed below.

Frist, $\frac{\partial Y_{It}}{\partial K_t} = N_{It}^\gamma \frac{\partial A_{It}}{\partial K_t} + A_{It} * \gamma N_{it}^{\gamma-1} * \frac{\partial N_{It}}{\partial K_t}$, where $\frac{\partial N_{It}}{\partial K_t} > 0$ and $\frac{\partial A_{It}}{\partial K_t} = \frac{1}{2} > 0$.

Hence, $\frac{\partial Y_{It}}{\partial K_t} > 0.$

Second, it is easy to derive that

$$\frac{\partial Y_{It}}{\partial A_{Ft}} = N_{It}^\gamma \frac{\partial A_{It}}{\partial A_{Ft}} + A_{It} * \gamma N_{It}^{\gamma-1} * \frac{\partial N_{It}}{\partial A_{Ft}}$$

$$= N_{It}^\gamma (\frac{1}{2} + \gamma * \frac{A_{It}}{N_{It}} * \frac{\partial N_{It}}{\partial A_{Ft}})$$

where

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[21] See Elgin and Oztunali (2012) for the definitions of the parameters used here.
[22] Assume that shocks in N_{Ft} are not related to shocks in K_t nor in A_{Ft}.

$$\frac{\partial N_{It}}{\partial A_{Ft}} = \Omega * A_{It}^{\frac{\gamma}{1-\gamma}}(A_{Ft})^{-\frac{1}{(1-\alpha)(1-\gamma)}} * \frac{1}{1-\gamma} * \left[\frac{1}{2} - \frac{1}{(1-\alpha)} * \frac{A_{It}}{A_{Ft}}\right]$$

and $\Omega = \left\{\frac{\gamma}{(1-\tau_t)(1-\alpha)}\left[\frac{\frac{1}{\beta}-1+\delta}{\alpha(1-\tau_t)}\right]^{\frac{\alpha}{1-\alpha}}\right\}^{\frac{1}{1-\gamma}}$.

Since $\alpha = 0.36$ and $A_{It} = \frac{1}{2}(A_{Ft} + K_t) + c$, we know that $\left[\frac{1}{2} - \frac{1}{(1-\alpha)} * \frac{A_{It}}{A_{Ft}}\right] < 0$ and $\frac{\partial N_{It}}{\partial A_{Ft}} <$ 0. This gives us $\frac{\partial Y_{It}}{\partial A_{Ft}} = N_{It}^{\gamma} * \left[\frac{1}{2} + \frac{\gamma}{1-\gamma} * \left(\frac{1}{2} - \frac{1}{(1-\alpha)} * \frac{A_{It}}{A_{Ft}}\right)\right]$. Hence, if $\frac{A_{It}}{A_{Ft}}$ falls below $\frac{(1-\alpha)}{2\gamma} \approx$ 0.75, $\frac{\partial Y_{It}}{\partial A_{Ft}}$ turns from positive to negative.

Since the comovement between Y_{It} and Y_{Ft} are largely driven by the assumption that $\dot{A}_{It} = \frac{1}{2}(\dot{K}_t + \dot{A}_{Ft})$, the DGE model is re-estimated by benchmarking N_{it} to survey-based self-employment. This gives the estimates of A_{It} and subsequently Y_{It}. The regression results for IV-2SLS models using DGE estimates benchmarked to self-employment are largely in line with those shown in the main text (Table 7).

Annex B. Calibrating DGE estimates using survey-based self-employment data

As shown in annex A and Elgin and Oztunali (2012), the employment in the informal sector, N_{It} has the following form:

$$N_{It} = \left\{\frac{\gamma A_{It}}{(1-\tau_t)(1-\alpha)A_{Ft}}\left[\frac{\frac{1}{\beta}-1+\delta}{\alpha(1-\tau_t)A_{Ft}}\right]^{\frac{\alpha}{1-\alpha}}\right\}^{\frac{1}{1-\gamma}} \quad \text{Eq(1)}.$$

After transforming Eq (1), A_{It} can be expressed as follows:

$$A_{It} = \frac{N_{It}^{1-\gamma}(1-\tau_t)(1-\alpha)A_{Ft}}{\gamma\left[\frac{\frac{1}{\beta}-1+\delta}{\alpha(1-\tau_t)A_{Ft}}\right]^{\frac{\alpha}{1-\alpha}}} \quad \text{Eq(2)}.$$

Following Loayza and Rigolini (2011) and Fiess et al. (2010), data on self-employment provided by Elgin et al. (2021) is used as estimates for N_{It} and calculate A_{It} using Eq (2). Following the earlier literature, α is assumed to be equal to 0.36 while δ takes the country average of the depreciation rates reported in Penn World Tables 9.1 (PWT, expanded using World Bank 2020 and WDI). Following Ihrig and Moe (2004), γ takes 0.425. Capital stock (K_t) and formal employment (N_{Ft}) are obtained from PWT 9.1. Assuming a balanced budget for the government, τ_t is obtained as the share of government spending in GDP reported in PWT 9.1.

Rewriting the production function of the informal sector (Y_{It}) using Eq(2), we find $Y_{It}$to be a function of A_{Ft} and N_{It}:

$$Y_{It} = N_{It} * \frac{(1 - \tau_t)(1 - \alpha)}{\gamma \left[\frac{\frac{1}{\beta} - 1 + \delta}{\alpha(1 - \tau_t)} \right]^{\frac{\alpha}{1 - \alpha}}} * (A_{Ft})^{\frac{1}{1 - \alpha}}$$

Which gives $\frac{\partial Y_{It}}{\partial A_{Ft}} > 0$. Since $\frac{\partial Y_{Ft}}{\partial A_{Ft}} > 0$, it is possible that the DGE estimates will move procyclically in the presence of large shocks in formal productivity while other type of shocks is absent. However, when other type of shocks also occurs at the same time, Y_{It} may not move procyclically. For instance, if N_{It} and N_{Ft}experienced shocks in different directions in the same time, Y_{It} might move countercyclically in the absence of other types of shocks.

Figure 1 Formal and informal economy business cycles

A. Shares of informal economy

Percent of GDP/employment
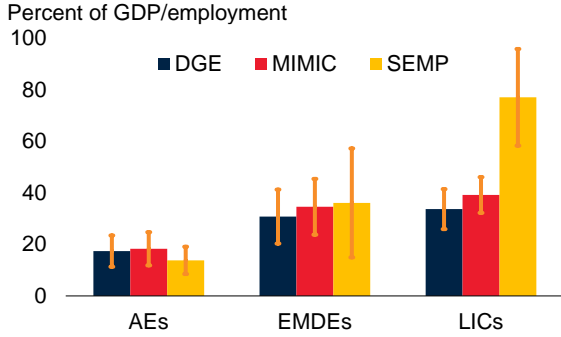
B. Changes in shares of informal economy during formal economy upturns and downturns in EMDEs

Percentage points / Percentage points
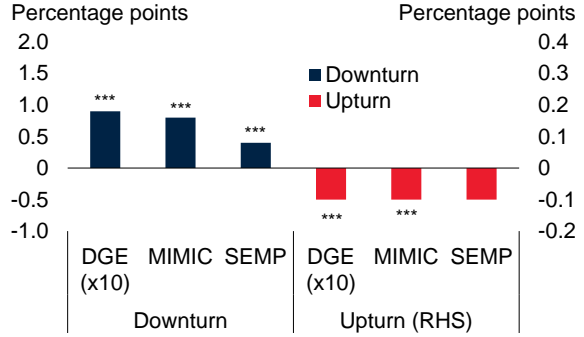
C. Output growth during formal economy upturns and downturns in EMDEs

Percent
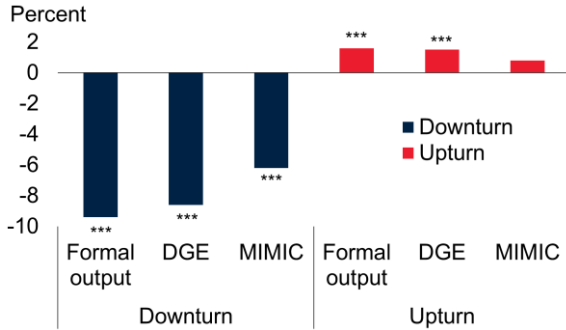
D. Employment growth during formal economy upturns and downturns in EMDEs

Percent
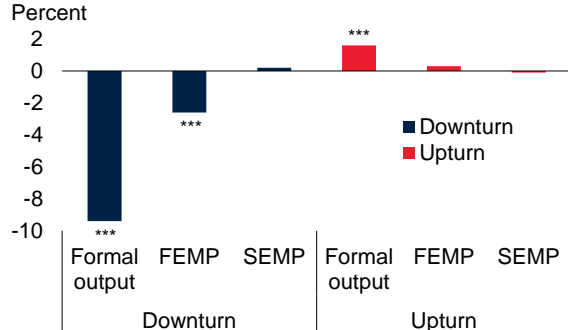
Sources: Penn World Table 9.1; World Bank.

Note: Data are for 1990-2018. AEs = advanced economies; DGE = dynamic general equilibrium model estimates; EMDEs = emerging market and developing economies; FEMP = formal employment (proxied by total employment excluding self-employment); LICs = low-income countries; MIMIC = multiple indicators and multiple causes model estimates; SEMP = self-employment. "Downturn" refers to growth rates of official GDP below zero, while "upturn" refers to growth rates of official GDP equal to or above zero. In B-D, *** indicates that the group average is significantly different from zero at the 10 percent level.

A. Bars show unweighted group averages for the latest year available, with the whiskers showing +/-1 standard deviation.

B. Shares of informal output (in percent of official GDP) and informal employment (in percent of total employment) are first-differenced and demeaned to capture detrended annual changes. Bars show unweighted group averages of detrended annual changes in shares of informal output/informal employment. Results for DGE-based estimates are shown in tenths.

C.D. Levels of output and employment in both formal and informal economies are logged, first-differenced and demeaned to capture detrended annual growth rates. Bars show unweighted group averages of detrended annual growth rates of output/employment levels.

Table 1 Lag and contemporaneous correlations

	Cyclical components			
	Formal output	t(-2)	t(-1)	t(0)
Informal output	Full sample	0.19***	0.63***	0.98***
(DGE-based estimates)	AEs	0.11***	0.65***	0.99***
	EMDEs	0.20***	0.63***	0.98***
Informal output	Full sample	0.28***	0.55***	0.78***
(MIMIC-based estimates)	AEs	0.29***	0.52***	0.69***
	EMDEs	0.28***	0.55***	0.79***
Formal employment	Full sample	0.07***	0.14***	0.17***
	AEs	0.30***	0.63***	0.69***
	EMDEs	0.05**	0.11***	0.13***
Informal employment	Full sample	-0.01	0.01	0.03*
	AEs	0.01	0.14***	0.21***
	EMDEs	-0.02	-0.01	0.01

Notes: AEs = advanced economies; DGE = dynamic general equilibrium model estimates; EMDEs = emerging market and developing economies; MIMIC = multiple indicators and multiple causes model estimates. Significant levels are * $p<0.10$, ** $p<0.05$, *** $p<0.01$. Each cells shows the correlation between the cyclical components of formal-economy output (in logs, of year t(-2), t(-1) and t(0)) and the cyclical components of informal-economy output, formal employment (i.e. total employment excl. self-employment) and informal employment proxied by self-employment (in logs, of year t(0)) listed in the first column. Data are for 1990-2018.

Table 2 Dynamic factor model: variance explained by the common factor
(In percent of total variance)

		Median	Mean	S.E.
Formal output	Full sample	40.49	40.37	1.71
	AEs	39.73	37.75	2.70
	EMDEs	41.32	41.41	2.13
Informal output (DGE-based estimates)	Full sample	40.18	39.25	1.75
	AEs	39.78	37.61	2.68
	EMDEs	40.18	39.89	2.21
Informal output (MIMIC-based estimates)	Full sample	22.38	24.10	1.69
	AEs	12.22	18.43	2.86
	EMDEs	23.47	26.35	2.02
Formal employment	Full sample	9.11	14.40	1.36
	AEs	20.21	22.11	2.71
	EMDEs	5.61	11.35	1.45
Informal employment	Full sample	2.56	5.75	0.78
	AEs	3.35	5.12	1.09
	EMDEs	2.36	5.99	1.00

Notes: AEs = advanced economies; DGE = dynamic general equilibrium model estimates; EMDEs = emerging market and developing economies; MIMIC = multiple indicators and multiple causes model estimates. All data series are transformed into cyclical components and standardized before the estimations. In the first two columns, the median (mean) fraction of variance explained by the common dynamic factor in each group is reported. We assume that in each country, official GDP, DGE, MIMIC, formal employment (i.e. total employment excl. Self-employment) and informal employment (i.e. self-employment) share one common dynamic factor with AR(1) process (suggested by the estimation results). The sample standard errors are shown in the last column. Data are for 1990-2018.

Table 3 Coincidence of formal and informal business cycle phases
(In percent of total country-year pairs)

	Phase of the informal business cycle (DGE-based estimates)			Phase of the informal business cycle (MIMIC-based estimates)		
	Recession	Expansion	Total	Recession	Expansion	Total
Phase of the formal business cycle						
Recession	99	1	100	83	17	100
Expansion	5	95	100	6	94	100
In same phase	96			91		
	Phase of the formal employment cycle			Phase of the informal employment cycle		
	Recession	Expansion	Total	Recession	Expansion	Total
Phase of the formal business cycle						
Recession	72	28	100	46	54	100
Expansion	24	76	100	44	56	100
In same phase	75			54		

Note: Data are for 1990-2018. DGE = dynamic general equilibrium model estimates; MIMIC = multiple indicators and multiple causes model estimates. Business phases and turning points are identified as in Elgin et al. (forthcoming). Recessions are the periods from peak to trough while expansions are the periods from trough to peak (Claessens et al. 2012). The cells show the percentage of formal "recession" ("expansion") phases that are accompanied with informal "recession" ("expansion") phases. "In same state" show the percentage of cases where formal and informal business cycles are in the same phase. Formal employment is total employment excluding self-employment, while informal employment is proxied by self-employment.

Table 4 IV-2SLS regression: Baseline model

	DGE			MIMIC			Formal employment			Informal employment		
	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	[10]	[11]	[12]
2nd stage Dep Var: Informal Output/Employment												
	Full	AEs	EMDEs	Full	AEs	EMDEs	Full	AEs	EMDEs	Full	AEs	EMDEs
Official GDP	0.55***	0.75***	0.51***	0.42***	0.65***	0.40***	0.56**	0.49***	0.54*	-0.06	0.11	-0.09
	(0.05)	(0.07)	(0.05)	(0.04)	(0.05)	(0.05)	(0.25)	(0.09)	(0.30)	(0.16)	(0.14)	(0.20)
With controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country dummy	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year dummy	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Kleibergen-Paap rk LM stat	29.81***	14.10***	24.44***	30.58***	13.99***	25.00***	36.25***	14.01***	29.10***	36.25***	14.01***	29.10***
Cragg-Donald Wald F stat	192.96	100.52	141.77	203.31	102.65	148.74	228.24	99.56	155.95	228.24	99.56	155.95
Obs	2,947	637	2,310	2,847	629	2,218	2,263	626	1,635	2,263	626	1,635
R-squared	0.50	0.79	0.47	0.37	0.62	0.35	0.05	0.60	0.04	0.03	0.10	0.04
1st stage Dep Var: Official GDP												
Terms of trade	0.09***	0.45***	0.08***	0.09***	0.46***	0.09***	0.13***	0.46***	0.11***	0.13***	0.46***	0.11***
	(0.03)	(0.11)	(0.03)	(0.03)	(0.11)	(0.03)	(0.03)	(0.11)	(0.03)	(0.03)	(0.11)	(0.03)
Export	0.13**	0.07	0.12*	0.15**	0.07	0.13*	0.23***	0.06	0.22***	0.23***	0.06	0.22***
	(0.07)	(0.15)	(0.07)	(0.07)	(0.15)	(0.07)	(0.07)	(0.15)	(0.08)	(0.07)	(0.15)	(0.08)
Gov consumption	0.14***	0.24***	0.13***	0.14***	0.24***	0.14***	0.16***	0.23***	0.15***	0.16***	0.23***	0.15***
	(0.02)	(0.04)	(0.03)	(0.02)	(0.04)	(0.03)	(0.02)	(0.04)	(0.02)	(0.02)	(0.04)	(0.02)
With controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country dummy	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year dummy	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
F-stats	17.06***	26.57***	13.78***	16.84***	26.89***	13.53***	24.39***	26.36***	19.01***	24.39***	26.36***	19.01***
Obs	2,947	637	2,310	2,847	629	2,218	2,263	626	1,635	2,263	626	1,635

Notes: Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1. AEs = advanced economies; DGE = dynamic general equilibrium model estimates; EMDEs = emerging market and developing economies; MIMIC = multiple indicators and multiple causes model estimates. First-stage F-stat show whether the concerning variable is a weak instrumental variable (IV), with a higher value suggesting a stronger IV. The equation is exactly identified. Kleibergen-Paap rk LM statistic shows the results for under-identification test, where a rejection shows the instrument is relevant. Significant Cragg-Donald Wald F statistic also shows that the used instrument is strong. Formal employment is total employment (excl. self-employment). Informal employment is proxied by self-employment. All dependent variables, official GDP, export and government consumption are cyclical components (in logs) obtained using HP-filter. Terms of trade is cyclical component (in percent of trend) obtained using HP-filter. Official GDP, government consumption, terms of trade and export are lagged to deal with the endogeneity issue. The control variables include the growth rates of domestic credit to private sector and real investment. Constant term is included in all regression models. See Section 3.2 for detailed model specifications Full sample with period over 1990-2018 is used here.

Table 5 IV-2SLS: Trade-related instrumental variables

	DGE			MIMIC			Formal employment			Informal employment		
	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	[10]	[11]	[12]
2nd stage Dep Var: Informal Output/Employment												
	Full	AEs	EMDEs	Full	AEs	EMDEs	Full	AEs	EMDEs	Full	AEs	EMDEs
Official GDP	0.59***	0.85***	0.55***	0.37***	0.47***	0.36***	0.41*	0.45***	0.37	0.02	0.06	-0.00
	(0.06)	(0.08)	(0.06)	(0.04)	(0.08)	(0.05)	(0.21)	(0.12)	(0.25)	(0.18)	(0.18)	(0.21)
With controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country dummy	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year dummy	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Kleibergen-Paap rk LM stat	30.04***	12.68***	24.80***	29.98***	12.59***	24.47***	36.83***	12.70***	29.80***	36.83***	12.70***	29.80***
Cragg-Donald Wald F stat	219.91	68.93	165.86	228.36	68.25	171.71	233.65	65.81	166.72	233.65	65.81	166.72
Obs	3,009	637	2,372	2,918	629	2,289	2,329	626	1,701	2,329	626	1,701
R-squared	0.50	0.79	0.47	0.36	0.62	0.34	0.06	0.60	0.05	0.03	0.09	0.04
1st stage Dep Var: Official GDP												
Terms of trade	0.16**	0.16	0.14**	0.17***	0.17	0.15**	0.25***	0.15	0.22***	0.25***	0.15	0.22***
	(0.06)	(0.15)	(0.07)	(0.07)	(0.15)	(0.07)	(0.07)	(0.15)	(0.08)	(0.07)	(0.15)	(0.08)
Export	0.15***	0.24***	0.14***	0.16***	0.25***	0.15***	0.17***	0.24***	0.16***	0.17***	0.24***	0.16***
	(0.03)	(0.04)	(0.03)	(0.03)	(0.04)	(0.03)	(0.02)	(0.04)	(0.02)	(0.02)	(0.04)	(0.02)
With controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country dummy	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year dummy	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
F-stats	22.75***	23.46***	18.42***	23.35***	22.99***	18.78***	31.23***	23.08***	24.84***	31.23***	23.08***	24.84***
Obs	3,009	637	2,372	2,918	629	2,289	2,329	626	1,701	2,329	626	1,701

Notes: Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1. AEs = advanced economies; DGE = dynamic general equilibrium model estimates; EMDEs = emerging market and developing economies; MIMIC = multiple indicators and multiple causes model estimates. First-stage F-stat show whether the concerning variable is a weak instrumental variable (IV), with a higher value suggesting a stronger IV. KP (Kleibergen-Paap) rk LM statistic shows the results for under-identification test, where a rejection shows the instrument is relevant. Significant CD (Cragg-Donald) Wald F statistic also shows that the used instrument is strong. Formal employment is total employment (excl. self-employment). Informal employment is proxied by self-employment. All dependent variables, official GDP, export and government consumption are cyclical components (in logs) obtained using HP-filter. Terms of trade is cyclical component (in percent of trend) obtained using HP-filter. Official GDP, government consumption, terms of trade and export are lagged to deal with the endogeneity issue. The control variables include the growth rates of domestic credit to private sector and real investment. Constant term, country and year dummies are included in all regression models and in both stages of regressions. See Section 3.2 for detailed model specifications. Full sample with period over 1990-2018 is used here.

Table 6 System GMM regression

	DGE			MIMIC			Formal employment			Informal employment		
	[1] Full	[2] AEs	[3] EMDEs	[4] Full	[5] AEs	[6] EMDEs	[7] Full	[8] AEs	[9] EMDEs	[10] Full	[11] AEs	[12] EMDEs
Official GDP	0.68***	0.75**	0.72***	0.49***	0.51***	0.52***	0.38***	0.36	0.36***	0.06	-0.10	-0.07
	(0.04)	(0.34)	(0.06)	(0.03)	(0.04)	(0.04)	(0.08)	(0.27)	(0.11)	(0.09)	(0.30)	(0.12)
Investment growth	0.03***	0.09***	0.03***	0.03***	0.05***	0.03***	0.01	0.02	0.00	-0.00	-0.01	-0.00
	(0.01)	(0.03)	(0.01)	(0.00)	(0.01)	(0.00)	(0.01)	(0.02)	(0.01)	(0.01)	(0.02)	(0.01)
Credit growth	0.02***	0.01	0.02***	0.01***	0.00	0.01***	-0.00	0.00	-0.01	0.02	-0.01	0.03*
	(0.01)	(0.01)	(0.01)	(0.00)	(0.00)	(0.00)	(0.01)	(0.00)	(0.01)	(0.01)	(0.01)	(0.01)
Obs	4,074	892	3,182	3,781	834	2,947	3,070	858	2,190	3,070	858	2,190
Number of countries	157	35	122	154	35	119	148	35	112	148	35	112
Number of instruments	204.00	135.00	135.00	198.00	79.00	153.00	110.00	84.00	110.00	110.00	84.00	110.00
AR(1)	0.00	0.16	0.00	0.00	0.01	0.00	0.27	0.41	0.27	0.02	0.09	0.04
AR(2)	0.51	0.33	0.70	0.51	0.11	0.70	0.01	0.04	0.01	0.00	0.00	0.01

Notes: Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1. AEs = advanced economies; DGE = dynamic general equilibrium model estimates; EMDEs = emerging market and developing economies; MIMIC = multiple indicators and multiple causes model estimates. Formal employment is total employment (excl. self-employment). Informal employment is proxied by self-employment. All dependent variables and official GDP are cyclical components (in logs) obtained using HP-filter. The control variables include the growth rates of domestic credit to private sector and real investment. Official GDP is lagged to deal with the endogeneity issue. Constant term is included in all regression models. Data are for 1990-2018 here.

Table 7 IV-2SLS: DGE estimates benchmarked to self-employment

	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]
2nd stage Dep Var: Informal Output (DGE estimates benchmarked to self-employment)									
	Full	AEs	EMDEs	Full	AEs	EMDEs	Full	AEs	EMDEs
Official GDP	0.56**	0.46***	0.62**	0.77**	0.62***	0.83**	0.43	0.02	0.55*
	(0.24)	(0.16)	(0.30)	(0.31)	(0.23)	(0.39)	(0.27)	(0.27)	(0.31)
With controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country dummy	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year dummy	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Kleibergen-Paap rk LM stat	32.97***	14.01***	25.59***	31.74***	12.70***	24.42***	27.10***	7.51***	20.99***
Cragg-Donald Wald F stat	239.49	99.56	155.36	201.97	65.81	135.58	338.75	73.41	219.28
Obs	2,054	626	1,427	2,090	626	1,463	2,381	857	1,523
R-squared	0.08	0.40	0.07	0.08	0.40	0.06	0.09	0.26	0.08
1st stage Dep Var: Official GDP									
Terms of trade	0.25***	0.06	0.24***	0.29***	0.15	0.25***			
	(0.07)	(0.15)	(0.08)	(0.08)	(0.15)	(0.09)			
Export	0.17***	0.23***	0.16***	0.19***	0.24***	0.18***			
	(0.02)	(0.04)	(0.03)	(0.03)	(0.04)	(0.03)			
Government consumption	0.19***	0.46***	0.16***				0.26***	0.35***	0.23***
	(0.03)	(0.11)	(0.03)				(0.03)	(0.10)	(0.03)
With controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country dummy	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year dummy	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
F-stats	38.24***	26.36***	28.32***	29.13***	23.08***	21.61***	61.43***	12.74***	45.60***
Obs	2,054	626	1,427	2,090	626	1,463	2,381	857	1,523

Notes: Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1. AEs = advanced economies; DGE = dynamic general equilibrium model estimates; EMDEs = emerging market and developing economies; MIMIC = multiple indicators and multiple causes model estimates. First-stage F-stat show whether the concerning variable is a weak instrumental variable (IV), with a higher value suggesting a stronger IV. The equation is exactly identified. Kleibergen-Paap rk LM statistic shows the results for under-identification test, where a rejection shows the instrument is relevant. Significant Cragg-Donald Wald F statistic also shows that the used instrument is strong. The dependent variable (DGE estimates benchmarked to self-employment), official GDP, export and government consumption are cyclical components (in logs) obtained using HP-filter. Terms of trade is cyclical component (in percent of trend) obtained using HP-filter. Official GDP, government consumption, terms of trade and export are lagged to deal with the endogeneity issue. The control variables include the growth rates of domestic credit to private sector and real investment. Constant term is included in all regression models. See Section 3.2 for detailed model specifications. Full sample with period over 1990-2018 is used here.

Annex Tables.

Table A.1 Table of Descriptive Statistics

Variables	Definition	Source	Number of countries	Time	Mean	Median
DGE-based estimates	DGE model-based estimates for informal output (in percent of official GDP)	Elgin et al. (2021)	158	1990-2018	31.8	31.6
MIMIC-based estimates	MIMIC model-based estimates for informal output (in percent of official GDP)	Elgin et al. (2021)	160	1993-2018	33.3	33.5
Informal employment	Self-employment (in percent of total employment).	Elgin et al. (2021)	179	1990-2018	31.0	25.8
Official GDP	Real GDP at constant 2011 national prices (in mil. 2011 US$)	PWT 9.1, expanded using World Bank (2020) and WDI.	181	1990-2018	425948.4	44369.0
Terms of trade	Net barter terms of trade index (2000=100)	World Development Indicators (WDI)	196	1990-2018	112.4	100.9
Export	Exports of goods and services (in constant mil. 2010 US$)	World Development Indicators	184	1990-2018	94734.4	12200.3
Gov consumption	General government final consumption expenditure (in constant mil. 2010 US$)	World Development Indicators	173	1990-2018	66502.8	5114.0
Investment growth	Gross fixed capital formation (annual growth rates, %)	PWT 9.1, expanded using WDI.	190	1990-2018	0.07	0.04
Credit growth	Credit growth rates	World Development Indicators	171	1990-2018	0.08	0.06
Total employment	Number of persons engaged (in millions)	PWT 9.1, expanded using World Bank (2020), ILO, Haver Analytics and other sources.	178	1990-2018	16.2	3.2

Table A.2 Synchronization of turning points in formal and informal business cycles
(In percent of country-year pairs with turning points)

Turning points of formal business cycles	Turning points of informal output business cycle (DGE-based estimates)		Turning points of informal output business cycle (MIMIC-based estimates)	
	Trough	Peak	Trough	Peak
Trough	71	0	37	1
Peak	0	67	2	36

Turning points of formal business cycles	Turning points of the formal employment cycle		Turning points of the informal employment cycle	
	Trough	Peak	Trough	Peak
Trough	14	3	8	10
Peak	3	19	8	8

Notes: Data are for 1990-2018. Trough and peaks are identified as in Elgin et al. (2021) where the BBQ method is used to identify those turning points. The cells show the share of formal peaks (or troughs) that happen to be informal peaks (or troughs).

Table A.3 Probit: formal and informal recessions

Dependent variable: In an informal recession	DGE			MIMIC			Formal employment			Informal employment		
	[1] Full	[2] AEs	[3] EMDEs	[4] Full	[5] AEs	[6] EMDEs	[7] Full	[8] AEs	[9] EMDEs	[10] Full	[11] AEs	[12] EMDEs
In a formal recession	0.32***	0.41***	0.32***	0.25***	0.35***	0.23***	0.16***	0.22***	0.12***	0.01	0.05	-0.00
	(0.01)	(0.05)	(0.01)	(0.01)	(0.05)	(0.01)	(0.02)	(0.05)	(0.03)	(0.03)	(0.07)	(0.03)
Investment growth	-0.01	-0.03	-0.00	-0.03	-0.30*	-0.03	-0.11***	-0.89***	-0.04*	-0.14***	-0.48***	-0.10***
	(0.02)	(0.14)	(0.01)	(0.02)	(0.16)	(0.02)	(0.03)	(0.16)	(0.02)	(0.04)	(0.15)	(0.03)
Credit growth	-0.01	-0.19**	-0.01	-0.00	-0.44*	0.01	-0.07**	-0.20	-0.06*	0.06*	-0.02	0.07**
	(0.02)	(0.09)	(0.02)	(0.02)	(0.25)	(0.02)	(0.03)	(0.16)	(0.03)	(0.03)	(0.11)	(0.03)
Observations	3,495	632	2,640	2,381	372	1,872	3,196	728	2,341	3,185	855	2,330
Pseudo R-sq	0.62	0.71	0.60	0.43	0.40	0.46	0.18	0.37	0.15	0.17	0.17	0.15

Notes: Standard errors clustered at the country level in parentheses, *** p<0.01, ** p<0.05, * p<0.1. Data are for 1990-2018. AEs = advanced economies; DGE = dynamic general equilibrium model estimates; EMDEs = emerging market and developing economies; MIMIC = multiple indicators and multiple causes model estimates. Average marginal effects are reported in the cells with corresponding standard errors reported in brackets. Country and year dummies are included. Recessions are identified as in Elgin et al. (forthcoming), where BBQ method is used to identify peaks and troughs of business cycles and recessions are defined as the period from peak to trough (Claessens et al. 2012). Formal employment shows "total employment (excl. self-employment)". Informal employment is proxied by "self-employment". The control variables include the growth rates of domestic credit to private sector and real investment. The probit model has the following form: $Pr(ISREC_{it} = 1) = \Phi(\alpha + \beta FS_{it} + \boldsymbol{\theta X_{it}} + \pi_i + \mu_t + \epsilon_{it})$, where $ISREC_{it}$ is a dummy variable that equals one when the informal sector in country i and year t is in recession, and zero otherwise. FS_{it} is a dummy representing recession in the formal economy, and $\boldsymbol{X_{it}}$ is a vector of control variables. Following Elgin and Oztunali (2012 and 2014), $\boldsymbol{X_{it}}$ includes the annual growth rates of real investment and domestic credit to the private sector. All regressions include country dummies (π_i) and year dummies (μ_t) to control for macro trends across countries in a certain year and factors that are country specific.

Table A.4 Probit: formal recession and the start of informal recessions

Dependent variable: Start an informal recession	DGE			MIMIC			Formal employment			Informal employment		
	[1] Full	[2] AEs	[3] EMDEs	[4] Full	[5] AEs	[6] EMDEs	[7] Full	[8] AEs	[9] EMDEs	[10] Full	[11] AEs	[12] EMDEs
In a formal recession	0.27***	0.39***	0.28***	0.21***	0.37***	0.20***	0.11***	0.17***	0.08***	-0.01	0.02	-0.01
	(0.01)	(0.03)	(0.01)	(0.01)	(0.06)	(0.01)	(0.02)	(0.05)	(0.02)	(0.03)	(0.07)	(0.03)
Investment growth	0.02*	0.35***	0.01	0.00	-0.07	-0.00	-0.09**	-0.54***	-0.06*	-0.11***	-0.17	-0.10***
	(0.01)	(0.09)	(0.01)	(0.02)	(0.13)	(0.02)	(0.04)	(0.15)	(0.03)	(0.03)	(0.18)	(0.03)
Credit growth	-0.01	-0.19*	-0.00	0.00	-0.29*	0.01	-0.01	-0.01	-0.01	0.06**	0.07	0.06**
	(0.02)	(0.10)	(0.02)	(0.02)	(0.18)	(0.02)	(0.02)	(0.12)	(0.03)	(0.03)	(0.08)	(0.03)
Observations	3,096	409	2,354	2,307	281	1,823	2,902	482	2,153	2,749	637	2,027
Pseudo R-sq	0.61	0.74	0.59	0.40	0.32	0.45	0.13	0.34	0.10	0.10	0.10	0.10

Notes: Standard errors clustered at the country level in parentheses, *** p<0.01, ** p<0.05, * p<0.1. Data are for 1990-2018. AEs = advanced economies; DGE = dynamic general equilibrium model estimates; EMDEs = emerging market and developing economies; MIMIC = multiple indicators and multiple causes model estimates. Average marginal effects are reported in the cells with corresponding standard errors reported in brackets. Country and year dummies are included. Recessions are identified as in Elgin et al. (forthcoming), where BBQ method is used to identify peaks and troughs of business cycles and recessions are defined as the period from peak to trough (Claessens et al. 2012). Formal employment shows "total employment (excl. self-employment)". Informal employment is proxied by "self-employment". The control variables include the growth rates of domestic credit to private sector and real investment. The probit model has the same form as in table A.3 but differs in the definition of $ISREC_{it}$. Here $ISREC_{it}$ is a dummy variable that equals one when the informal sector in country i and year t is in the start of a recession, and zero otherwise.

Table A.5 IV-2SLS regression: Fiscal actions in the formal economy

	DGE			MIMIC			Formal employment			Self-employment		
	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	[10]	[11]	[12]
2nd stage Dep Var: Informal Output/Employment												
	Full	AEs	EMDEs	Full	AEs	EMDEs	Full	AEs	EMDEs	Full	AEs	EMDEs
Official GDP	0.54***	0.63***	0.52***	0.56***	0.98***	0.54***	0.71**	0.64***	0.71*	-0.17	-0.08	-0.17
	(0.10)	(0.14)	(0.11)	(0.09)	(0.15)	(0.10)	(0.33)	(0.11)	(0.38)	(0.23)	(0.22)	(0.26)
With controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country dummy	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year dummy	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Kleibergen-Paap rk LM stat	12.03***	7.43***	10.53***	12.35***	7.29***	10.80***	29.03***	7.51***	22.94***	29.03***	7.51***	22.94***
Cragg-Donald Wald F stat	239.14	57.29	173.92	255.07	57.63	186.54	304.48	73.41	205.80	304.48	73.41	205.80
Obs	3,357	882	2,475	3,197	826	2,371	2,596	857	1,737	2,596	857	1,737
R-squared	0.52	0.75	0.50	0.45	0.12	0.46	0.01	0.53	0.00	0.02	0.04	0.03
1st stage Dep Var: Official GDP												
Government consumption	0.13***	0.29***	0.12***	0.13***	0.30***	0.12***	0.19***	0.35***	0.18***	0.19***	0.35***	0.18***
	(0.04)	(0.09)	(0.04)	(0.04)	(0.10)	(0.04)	(0.03)	(0.10)	(0.03)	(0.03)	(0.10)	(0.03)
With controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country dummy	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year dummy	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
F-stats	11.50***	9.74***	10.24***	11.55***	9.16***	10.30***	38.07***	12.74***	30.18***	38.07***	12.74***	30.18***
Obs	3,357	882	2,475	3,197	826	2,371	2,596	857	1,737	2,596	857	1,737

Notes: Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1. AEs = advanced economies; DGE = dynamic general equilibrium model estimates; EMDEs = emerging market and developing economies; MIMIC = multiple indicators and multiple causes model estimates. First-stage F-stat show whether the concerning variable is a weak instrumental variable (IV), with a higher value suggesting a stronger IV. The Kleibergen-Paap rk LM statistic indicates that the test for under-identification is rejected and, hence, the instrumental variable is relevant. The significant Cragg-Donald Wald F statistic also suggests that the used instrument is strong. Formal employment shows "total employment (excl. self-employment)". Informal employment is proxied by "self-employment". All dependent variables, official GDP and government consumptions are cyclical components (in logs) obtained using the Hodrick-Prescott-filter. Official GDP and government consumptions are lagged to deal with the endogeneity issue. The control variables include the growth rates of domestic credit to private sector and real investment. Data are for 1990-2018.

Table A.6 Fixed-effect estimator regressions

	DGE			MIMIC			Formal employment			Informal employment		
	[1] Full	[2] AEs	[3] EMDEs	[4] Full	[5] AEs	[6] EMDEs	[7] Full	[8] AEs	[9] EMDEs	[10] Full	[11] AEs	[12] EMDEs
Official GDP	0.60***	0.83***	0.58***	0.46***	0.46***	0.46***	0.24***	0.50***	0.18***	0.03	0.21***	-0.03
	(0.03)	(0.03)	(0.04)	(0.03)	(0.04)	(0.03)	(0.06)	(0.05)	(0.07)	(0.07)	(0.07)	(0.08)
Investment growth	0.03***	0.11***	0.03***	0.02***	0.04***	0.02***	-0.00	0.04***	-0.01	-0.00	0.02	-0.00
	(0.01)	(0.01)	(0.01)	(0.00)	(0.01)	(0.00)	(0.01)	(0.01)	(0.01)	(0.01)	(0.02)	(0.01)
Credit growth	0.03***	0.01*	0.03***	0.01***	0.00	0.01***	-0.00	0.01*	-0.01	0.02	-0.00	0.03
	(0.01)	(0.01)	(0.01)	(0.00)	(0.00)	(0.00)	(0.01)	(0.00)	(0.01)	(0.01)	(0.02)	(0.02)
Observations	4,074	892	3,182	3,781	834	2,947	3,070	858	2,190	3,070	858	2,190
Number of countries	157	35	122	154	35	119	148	35	112	148	35	112
R-sq	0.46	0.77	0.44	0.39	0.52	0.39	0.03	0.55	0.02	0.01	0.07	0.01
Adj. R-sq	0.45	0.76	0.43	0.39	0.50	0.38	0.02	0.53	0.01	0.00	0.04	0.00

Notes: Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1. AEs = advanced economies; DGE = dynamic general equilibrium model estimates; EMDEs = emerging market and developing economies; MIMIC = multiple indicators and multiple causes model estimates. All dependent variables and official (real) GDP are cyclical components (in logs) obtained using HP-filter. Formal employment shows "total employment (excl. self-employment)". Informal employment is proxied by "self-employment". Full sample with period over 1990-2018 is used here. The fixed-effect model estimated here has the following form:$Y_{it} = \alpha + \beta GDP_{it-1} + \theta X_{it} + \pi_i + \mu_t + \epsilon_{it}$, where Y_{it} is the cyclical component of informal GDP or employment derived using the Hodrick-Prescott-filter, and GDP_{it-1} is the Hodrick-Prescott-filtered cyclical component of official GDP. The cyclical component of official GDP is lagged to deal with endogeneity. X_{it} is a vector of control variables, including the annual growth rates of real investment and domestic credit to the private sector. Data for investment is provided by PWT 9.1, spliced with data from World Development Indicators (WDI 2020), and credit data are obtained from WDI (2020). Country fixed effects (π_i) are used here with year dummies (μ_t) included.

Table A.7 Lag and contemporaneous correlations of shares

		Cyclical components		
	Formal output	t(-2)	t(-1)	t(0)
Informal output shares	Full sample	-0.25***	-0.21***	-0.06***
(DGE-based estimates, in logs)	AEs	-0.18***	0.22***	0.49***
	EMDEs	-0.26***	-0.24***	-0.10***
Informal output shares	Full sample	-0.08***	-0.25***	-0.42***
(MIMIC-based estimates, in logs)	AEs	-0.05*	-0.36***	-0.63***
	EMDEs	-0.08***	-0.23***	-0.40***
Formal employment shares	Full sample	0.02	0.04**	0.05***
(in logs)	AEs	0.16***	0.24***	0.22***
	EMDEs	0.02	0.04**	0.05**
Informal employment shares	Full sample	-0.05***	-0.06***	-0.06***
(in logs)	AEs	-0.15***	-0.21***	-0.17***
	EMDEs	-0.05**	-0.07***	-0.07***

Notes: significant levels are * p<0.10, ** p<0.05, *** p<0.01. AEs = advanced economies; DGE = dynamic general equilibrium model estimates; EMDEs = emerging market and developing economies; MIMIC = multiple indicators and multiple causes model estimates. Each cells shows the correlation between the cyclical components of formal-economy output (in logs, of year t(-2), t(-1) and t(0)) and the cyclical components of informal output in percent of official GDP, formal employment (i.e. total employment excl. self-employment) in percent of total employment and informal employment proxied by self-employment in percent of total employment (of year t(0)) listed in the first column. Data are for 1990-2018.

Table A.8 IV-2SLS regression: Baseline model (shares of the informal economy)

	DGE			MIMIC			Formal employment			Informal employment		
	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	[10]	[11]	[12]
2nd stage Dep Var: Informal Output/Employment												
	Full	AEs	EMDEs	Full	AEs	EMDEs	Full	AEs	EMDEs	Full	AEs	EMDEs
Official GDP	-0.04***	-0.01	-0.04***	-0.13***	-0.14***	-0.11***	0.43*	0.07***	0.48*	-0.20	-0.38***	-0.16
	(0.01)	(0.02)	(0.01)	(0.03)	(0.03)	(0.03)	(0.24)	(0.03)	(0.28)	(0.17)	(0.14)	(0.20)
With controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country dummy	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year dummy	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
KP rk LM stat	29.81***	14.10***	24.44***	30.58***	13.99***	25.00***	26.24***	14.01***	29.10***	36.25***	14.01***	29.01***
CD Wald F stats	192.81***	100.52	141.77	203.31	102.65	148.74	228.24	99.56	155.95	228.24	99.56	155.95
Obs	2,947	552	2,310	2,847	629	2,218	2,263	626	1,635	2,263	541	1,635
R-squared	0.13	0.31	0.13	0.10	0.63	0.07	0.00	0.14	0.01	0.05	0.13	0.05
1st stage Dep Var: Official GDP												
Terms of trade	0.09***	0.34***	0.08***	0.09***	0.46***	0.09***	0.13***	0.46***	0.11***	0.13***	0.35***	0.11***
	(0.03)	(0.10)	(0.03)	(0.03)	(0.11)	(0.03)	(0.03)	(0.11)	(0.03)	(0.03)	(0.10)	(0.03)
Export	0.13**	0.09	0.12*	0.15**	0.07	0.13*	0.23***	0.06	0.22***	0.23***	0.08	0.22***
	(0.07)	(0.16)	(0.07)	(0.07)	(0.15)	(0.07)	(0.07)	(0.15)	(0.08)	(0.07)	(0.16)	(0.08)
Gov consumption	0.14***	0.24***	0.13***	0.14***	0.24***	0.14***	0.16***	0.23***	0.15***	0.16***	0.24***	0.15***
	(0.02)	(0.05)	(0.03)	(0.02)	(0.04)	(0.03)	(0.02)	(0.04)	(0.02)	(0.02)	(0.05)	(0.02)
With controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country dummy	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year dummy	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
F-stats	17.06***	13.91***	13.78***	16.84***	26.89***	13.53***	24.39***	26.36***	19.01***	24.39***	26.36***	19.01***
Obs	2,947	552	2,310	2,847	629	2,218	2,263	626	1,635	2,263	541	1,635

Notes: Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1. AEs = advanced economies; DGE = dynamic general equilibrium model estimates; EMDEs = emerging market and developing economies; MIMIC = multiple indicators and multiple causes model estimates. First-stage F-stat show whether the concerning variable is a weak instrumental variable (IV), with a higher value suggesting a stronger IV. The equation is exactly identified. Kleibergen-Paap (KP) rk LM statistic shows the results for under-identification test, where a rejection shows the instrument is relevant. Significant Cragg-Donald (CD) Wald F statistic also shows that the used instrument is strong. Formal employment is total employment (excl. self-employment). Informal employment is proxied by self-employment. All dependent variables (in shares of official GDP or in percent of total employment), official GDP, export and government consumption are cyclical components (in logs) obtained using HP-filter. Terms of trade is cyclical component (in percent of trend) obtained using HP-filter. Official GDP, government consumption, terms of trade and export are lagged to deal with the endogeneity issue. The control variables include the growth rates of domestic credit to private sector and real investment. See Section 3.2 for model specifications. Constant term is included in all regression models. Full sample with period over 1990-2018 is used here.

Table A.9 IV-2SLS regression: Trade-related instrumental variables (shares of the informal economy)

	DGE			MIMIC			Formal employment			Informal employment		
	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	[10]	[11]	[12]
2nd stage Dep Var: Informal Output/Employment												
	Full	AEs	EMDEs	Full	AEs	EMDEs	Full	AEs	EMDEs	Full	AEs	EMDEs
Official GDP	-0.02	0.06	-0.03*	-0.16***	-0.36***	-0.13***	0.30	0.08**	0.33	-0.09	-0.31*	-0.05
	(0.02)	(0.04)	(0.02)	(0.04)	(0.06)	(0.04)	(0.20)	(0.04)	(0.24)	(0.19)	(0.17)	(0.23)
With controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country dummy	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year dummy	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
KP rk LM stat	30.04***	8.92***	24.80***	29.98***	12.58***	24.47***	36.83***	12.70***	24.47***	36.83***	12.70***	24.47***
CD Wald F stats	219.91	68.92	165.86	228.36	68.26	171.71	233.65	65.81	171.71	233.65	65.81	171.71
Obs	3,009	637	2,372	2,918	629	2,289	2,329	626	1,701	2,329	626	1,701
R-squared	0.13	0.35	0.13	0.09	0.60	0.07	0.02	0.14	0.02	0.05	0.12	0.05
1st stage Dep Var: Official GDP												
Terms of trade	0.16**	0.17	0.14**	0.17***	0.17	0.15**	0.25***	0.15	0.22***	0.25***	0.15	0.22***
	(0.06)	(0.15)	(0.07)	(0.07)	(0.15)	(0.07)	(0.07)	(0.15)	(0.08)	(0.07)	(0.15)	(0.08)
Export	0.15***	0.24***	0.14***	0.16***	0.25***	0.15***	0.17***	0.24***	0.16***	0.17***	0.24***	0.16***
	(0.03)	(0.05)	(0.03)	(0.03)	(0.04)	(0.03)	(0.02)	(0.04)	(0.02)	(0.02)	(0.04)	(0.02)
With controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country dummy	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year dummy	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
F-stats	22.75***	13.94***	18.42***	23.35***	22.99***	18.78***	31.23***	23.08***	18.78***	31.23***	23.08***	18.78***
Obs	3,009	569	2,372	2,918	629	2,289	2,329	626	1,701	2,329	626	1,701

Notes: Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1. AEs = advanced economies; DGE = dynamic general equilibrium model estimates; EMDEs = emerging market and developing economies; MIMIC = multiple indicators and multiple causes model estimates. First-stage F-stat show whether the concerning variable is a weak instrumental variable (IV), with a higher value suggesting a stronger IV. KP (Kleibergen-Paap) rk LM statistic shows the results for under-identification test, where a rejection shows the instrument is relevant. Significant CD (Cragg-Donald) Wald F statistic also shows that the used instrument is strong. Formal employment is total employment (excl. self-employment). Informal employment is proxied by self-employment. All dependent variables (in shares of official GDP or in percent of total employment), official GDP, and export are cyclical components (in logs) obtained using HP-filter. Terms of trade is cyclical component (in percent of trend) obtained using HP-filter. Official GDP, terms of trade and export are lagged to deal with the endogeneity issue. Controls and detailed model specifications are as shown in Table 4. Constant term, country and year dummies are included in all regression models and in both stages of regressions. Full sample with period over 1990-2018 is used here. When DGE-based estimates are used in AEs, four outlier countries are dropped: LTU, LVA, EST, and SVK.