

Working in the Shadows: A Markov Switching Model of the Informal Labour Market

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The literature suggests that informal labour markets provide a much-needed safety net for displaced workers during economic downturns. This paper investigates the extent to which the informal labour market acts as a buffer during economic shocks in a small state. A Markov-switching process is used to model the relationship between the formal and informal labour markets over the business cycle. This paper adds to the debate surrounding the role of informal labour markets in the achievement of sustainable and inclusive development and provides evidence to support moving beyond the extension of social protection programmes as the key vehicle for formalisation.

Keywords: Informal labour; Labour market dynamics; Markov switching

JEL Codes: C32; J08; J46

1 Introduction

The informal sector is a large part of the economy in most developing countries. The sector is largely made up of small entities that utilise local resources, have fewer barriers to entry, normally family enterprises, operate in unregulated and competitive markets, labour intensive and based on informally acquired skills (Papola, 1980). Due to the relatively low barriers to entry these firms account for a significant proportion of economic activity as well as employment. For Latin America and the Caribbean, the size of the informal sector was estimated at 29-70 percent of overall economic activity (Maurizio, 2021).

Traditional economic models assume that the informal sector absorbs any surplus labour not utilised by the formal sector (Lewis, 1954). The informal sector is thought to be less technologically advanced and therefore is likely to shrink over time as the relatively more dynamic formal sector grows and expands. As a result, employment in the traditional sector should grow over time and persons employed in the informal sector would be absorbed by the formal sector.

While there is a long-term trend of persons leaving the informal sector to work in the formal sector, in the short-run the informal sector can act as a source of employment for persons unemployed in the traditional sector. If this occurs, then workers from the formal sector may voluntarily take-up informal employment. Because informal employment may be heterogeneous, workers may actually prefer “upper-tier”, “easy-entry” or “preferred to formal sector employment” employment in the informal sector, rather than employment in the formal sector (Fields, 2005). While it is somewhat counterintuitive,

i.e. workers might choose to work in the informal sector, it is quite logical if workers perceive the terms and conditions of their employment as better than the jobs they could potentially obtain in the formal sector.

Over the business cycle, the informal sector can also be a source of employment for persons unable to find jobs in the formal sector. Fernandez and Meza (2015) report that informal employment is countercyclical, lags the cycle and negatively correlated with formal employment in Mexico. The authors argue that this explains the low variability in employment over the business cycle in the country relative to Canada. One of the ways that this might occur is through the variability of wages in the informal sector. Guriev, Speciale and Tuccio (2019) notes that during the Great Recession wages in Italy would have declined resulting in a rise in employment in this sector. This reduction in wages can result in workers in the informal sector being worse-off since the informal sector has little economic protections (Horn, 2010).

Most studies investigate the link between formal and informal employment through surveys of just a particular region or sector of an economy. Using a novel database obtained from the Barbados National Insurance Scheme, this study investigates whether the informal sector can act as a buffer for job losses during periods of declining employment in the formal sector.

The study makes three main contributions to the literature. First, the paper provides an empirical analysis of the dynamics of the informal and formal labour in the event of shocks in a small open economy. Second, by using a Markov-switching process the paper endogenously models the relationship between formal and informal labour markets and

their connection to the business cycle. Finally, the paper will endeavour to contribute to a broader perspective on formalising the informal labour market, extending beyond its incorporation into social protection programs.

The remainder of the paper is structured as follows. Following the introduction, Section 2 provides a summary of the previous literature. Section 3 of the study outlines the methodological approach and the rationale while Section 4 offers a summary of the results. Section 5 of the study summarises the main results and outlines some policy conclusions emerging from the study.

2 Literature Review

The 1970's marked a turning point in international discourse on the informal economy. Work by prominent scholars such as Hart (1973) began to shed light on economic activities occurring outside the formal sector in the developing world. Their research highlighted the importance of informal activities for livelihoods, employment generation and economic survival in contexts where formal sector opportunities were limited. By the 1980's the International Labour Organisation and other international bodies began to take notice with the ILO's World Employment Programme initiating research on the informal sector. Influential studies such as "Urban Informal Sector" (1972) and "The Informal Sector Revisited" (1991) helped to shape the world-wide dialogue on the informal economy and its significance.

By 1993, the International Conference of Labour Statisticians introduced an international statistical definition of the "informal sector" which defined the informal sector as any employment and production occurring within unincorporated small and or unregistered enterprises (Chen and Vanek, 2013). A formal definition of the informal sector was to serve as a valuable tool for understanding, measuring, and addressing the challenges faced by informal workers worldwide focusing primarily on enterprises.

From 1997 onwards, however, the International Labour Office (ILO) initiated collaborative efforts with the Expert Group on Informal Sector Statistics (known as the Delhi Group), and the global network Women in Informal Employment: Globalizing and Organizing (WIEGO) to expand the concept and definition of the informal sector. Their objective was to encompass additional forms of informal employment that were not covered by the enterprise-based definition. These efforts aimed to include all aspects of work-related informality as observed in industrialised, transitioning, and developing economies, considering the dynamic nature of labour markets, particularly the employment arrangements of individuals classified as the working poor (Chen & Vanek, 2013).

By 2002, the International Labour Conference endorsed a new definition of informal employment that extended the focus from enterprises that are not legally regulated to employment relationships that are not legally regulated or socially protected. Informal employment therefore includes a range of self-employed persons who mainly work in unincorporated small or unregistered enterprises as well as a range of wage workers who are employed without employer or employee contributions to social protection (ILO, 2003). Yet as crucial as having a formal definition of the informal sector or labour is, it

does not tell us much about the role informal enterprises and workers play in development.

The literature identifies three broad views regarding the role informal economies play in society. Firstly, the romantic view of the informal sector found in the work of De Soto (1989) posits that informal firms are either actually or potentially extremely productive but held back by excessive government bureaucracy, lack of secure property rights and or an access to finance. Williams and Windebank (1998) builds on the work of De Soto and argue that informal labour can provide flexibility, autonomy and income opportunities for individuals who may not fit within traditional formal employment structures. The romantic view essentially argues informal enterprises and firms are similar to formalised firms but simply kept down by policy. If regulatory barriers are lowered and capital is made available through microfinance, informal business owners and workers would formalise, borrow and take advantage of the benefits official status offers to expand and spark economic growth (La Porta and Shleifer,2008).

The parasitic view of the informal economy in contrast to the romantic view is more sceptical of the informal economy's benefits to the development of a country. This view portrays the informal economy as a "parasite" that essentially thrives at the expense of the formal economy, undermining its growth, efficiency and ability to generate sustainable employment (Farrell, 2004). Castells and Portes (1989) in their seminal research present the view that the informal economy actively destabilises and erodes formal structures, perpetuates poverty and hinders social and economic development through tax evasion, labour exploitation, unfair competition. Using data from Latin American countries in the early 1990's, Loayza (1996) finds that as the size of the

informal economy increases it negatively affects growth by (1) reducing the availability of public services for everyone and by (2) by using the existing public services less efficiently. Other studies using similar datasets contend that the informal economy may actually amplify and prolong shocks and disturbances to the economy (Restrepo-Echavarria, 2014; Fernández & Meza, 2015). Fernandez and Meza (2015) in particular argue that the informal sector actually places a drag on the formal sector to limit productivity and economic growth. It can be disputed, however, that the negative effects of the presence of the informal sector are more nuanced than presented in the aforementioned studies. Informal activities are generally informed by the size of the economy, its level of economic development, tax burdens and rule of law (Schneider & Enste, 2000; Pratap & Quintin, 2006).

Positive effects of shadow economies must be considered as well in order to provide a balanced view of the phenomenon. The dual view recognises both the positive and negative aspects of the informal economic activities. It seemingly emerges as a response to the limitations of both the romanticised and parasitic views of the informal sector and attempts to strike the balance between acknowledging the important role of the sector whilst addressing any issues that may arise from operating outside formal regulations. Chen (2007) posits that the formal and informal sectors at some point fall on a continuum but are always inextricably linked. For instance, many formal enterprises hire wage workers under informal employment relations. These types of linkages are commonly witnessed in the construction industry where many workers work for formal enterprises through contracting or subcontracting arrangements. As long as such arrangements exist it is inadequate and incorrect to demarcate the informal and formal labour sectors as separate economic segments and or labour situations (Breman, 1976).

Naturally, out of the dualistic perspective springs copious research on how the informal economy behaves during crises and economic downturns (Blanton & Peksen, 2021; Colombo et al., 2016, 2019; Fiess et al., 2010; Leyva & Urrutia, 2023; Rigolini, 2011; Marcelino & Sans, 2023; Mróz, 2015). During financial crises the literature consistently finds that the informal economy acts as a safety net or cushion (Colombo et al., 2016, 2019; Fiess et al., 2010; Loayza & Rigolini, 2011) but only in the short run. They argue that the presence of the informal sector a year after the initial crisis or during the economy's recovery will hinder the recovery. According to the literature, the impact of productivity shocks on informal labour is more nuanced. The informal sector is highly responsive to productivity shocks both negative and positive and reacts differently to each shock. Bello (2002) posits that positive shocks, such as technological advancements or increases in demand for informal sector goods and services, can lead to increased productivity and growth in the informal economy. On the other hand, negative shocks, such as economic downturns or policy changes, can have adverse effects, leading to reduced productivity and employment in the informal sector. The most recent productivity shock, COVID-19 pandemic, saw the informal sector respond differently to developments. Containment measures did result in a decrease in the informal labour participation (Leyva & Urrutia 2023 ; Marcelino & Sans 2023) but it was also accompanied by a spike in the digitalisation of the informal economy (UNDP,2022).

This literature review provides a cursory analysis of informality, from initial attempts at defining the concept to theoretical frameworks that underpin a general understanding of the effects of informal sectors on development and the existing work on the sector's behaviour in times of crisis. The literature is extensive in this regard but gaps still remain.

The literature identifies several factors that contribute to the growth and persistence of the informal economy such as excessive regulation, burdensome bureaucracy, high taxes, corruption, underdeveloped social programmes and limited access to formal financial institutions but fails to address how the informal sector behaves in small economies with middle to high incomes and developed social protection programmes. This study attempts to fill that gap by empirically investigating how the relationship between informal labour and formal labour changes according to the business cycle. The study aims to contribute to the debate on formalisation of the informal sector by providing evidence to support moving beyond the parasitic view of the informal economy.

3 Empirical Methodology

The paper uses a Markov-switching model, which is normally utilised when it is observed that a series transitions over a finite set of unobserved states. These models allow the process to evolve along a different path in each state. Previous studies have used the approach to model the labour market (Krolzig, Marcellino, & Mizon, 2002), labour market dynamics over the business cycle (Schwartz, 2012) as well as Okun's Law (Holmes & Silverstone, 2006). The Markov-switching model can not only identify periods of downturn, but can also allow the relationship between formal and informal employment to change over these different states.

The general Markov-switching dynamic regression is of the form:

$$y_t = u_{st} + x_t\alpha + z_t\beta_{st} + u_s$$

(1)

where y_t is the variable of interest, u_{st} is the state-dependent intercept, x_t is a vector of exogenous variables with state-invariant coefficients α , z_t is a vector of exogenous variables with state-dependent coefficients β_{st} and u_s is an independent and identically distributed normal error with mean zero and state-dependent variance σ_s^2 .

The paper estimates a Markov Switching Autoregressive (MSAR) model to account for gradual transitions between states which is normally the case when quarterly data is used.

The model therefore now becomes:

$$y_t = u_{st} + x_t\alpha + z_t\beta_{st} + \phi_{1,st} (y_{t-1} - u_{st-1} + x_{t-1}\alpha + z_{t-1}\beta_{st-1}) + u_{st}$$

(2)

where $\phi_{i,st}$ are the state-dependent AR terms.

The authors use a simple proxy of informal labour since it is a latent variable. Formal employment in the study refers to workers who contribute to the national social security programme and assumes that the non-contributors to the national social security constitute informal employment; a common practice in the literature (Loayza,2007; Marcelino and Sans, 2023).

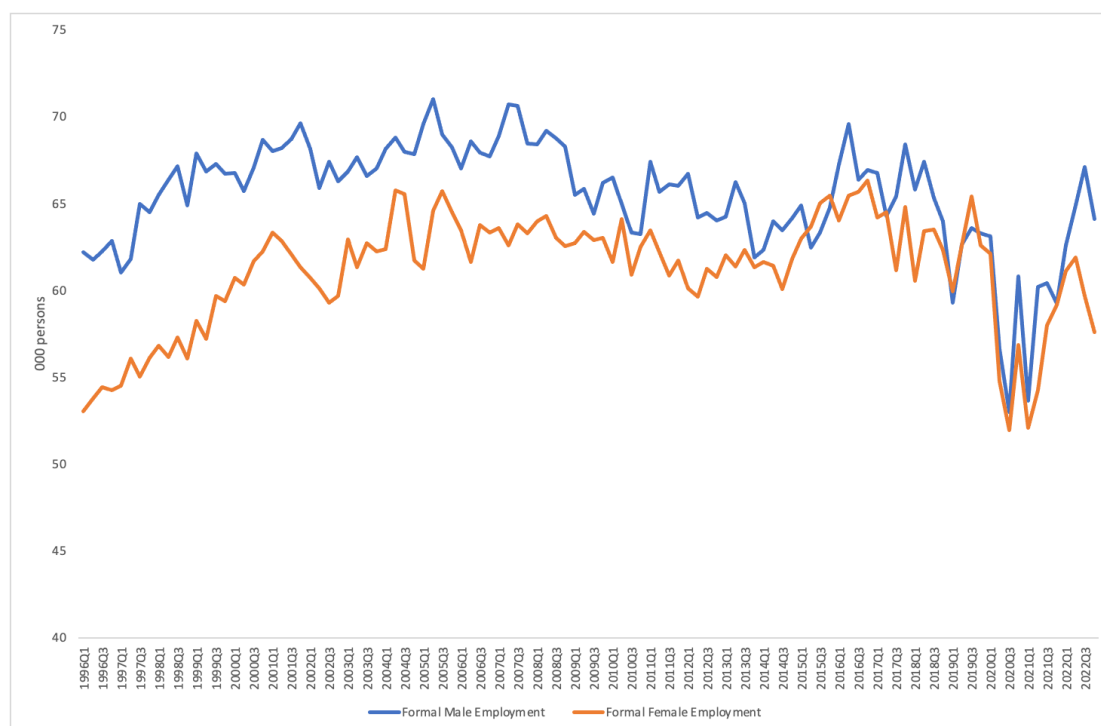
Labour variables naturally exhibit seasonality and are non-stationary. To account for this all labour variables were logged and then first differenced. Two dummies were also created due to unusual spikes in labour variables during the Global financial crisis 2009 and the COVID-19 pandemic 2020. The Schwarz's Bayesian information criterion (SBIC) was also used to choose the best model. Real GDP growth was used as a proxy for the business cycle. According to Sabarwal, Sinha, and Buvinic (2010) female and male labour markets respond differently to shocks so total informal labour was disaggregated to determine the relationship between informal and formal labour by gender.

The paper uses quarterly data (1996Q1-2022Q4) on total employed persons by gender, number of contributors by gender and Real GDP growth. Employment and real GDP data is sourced from the Barbados Statistical Service while the National Insurance Scheme provided the historical data on the number of contributors.

Generally male and female employment move together, but there are noticeable periods where employment by gender diverges. Female employment began the period approximately 15 percent below that of male employment. By the end of the review

period (2021), however, male and female employment were basically equivalent. The year 2022 witnessed a significant jump in male employment due to a pickup in the construction industry, pushing the figures apart once again.

Figure 1: Male and Female Employment

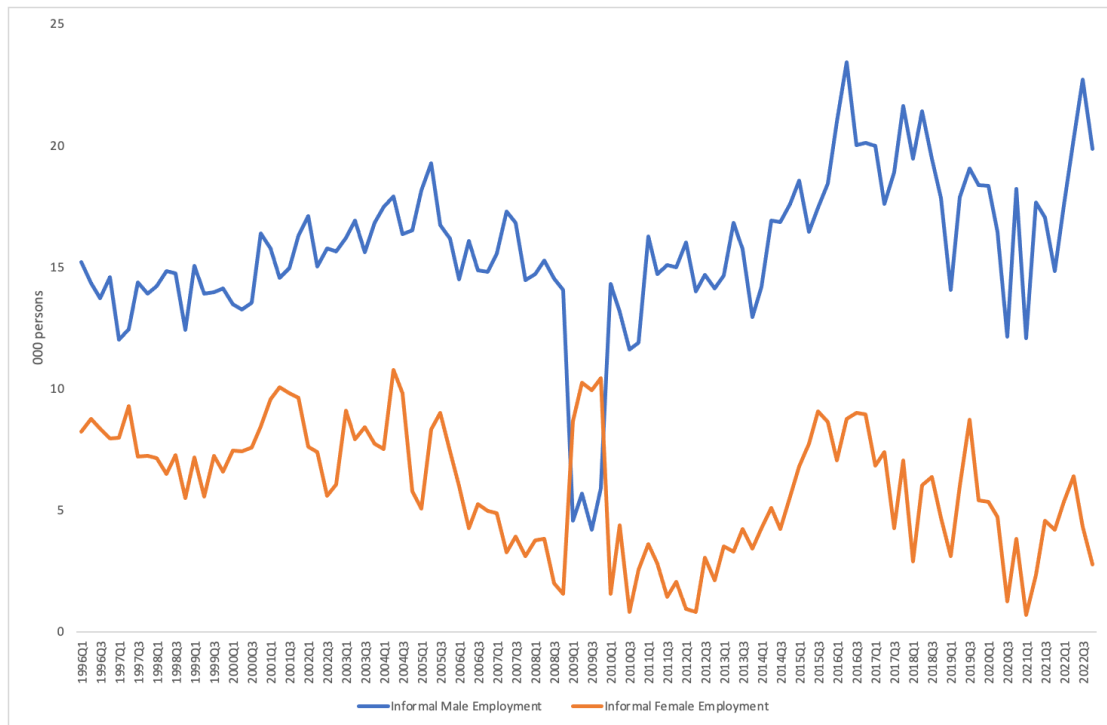


Source: Barbados Statistical Service

The number of males participating in the informal labour market was higher than that for females for much of the review period. On average, male employment was 25 percent higher than female employment, with the difference getting even larger by the end of the review period (75 percent). Unlike the chart for total employment, there is no clear correlation between the two series. For example, while male informal employment trended upwards during the period 2001 to 2005, female informal employment trended

downwards. Another example was in the wake of the 2008 global financial crisis, while female employment trended upwards, male employment simply fluctuated around the average for the period.

Figure 2: Male and Female Informal Employment

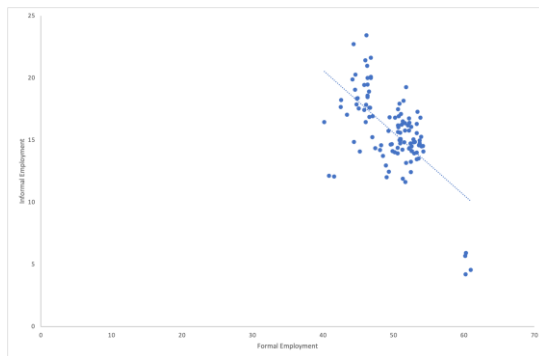


Source: Authors' Calculations

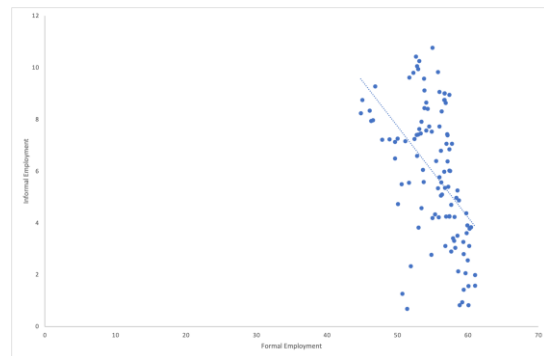
There appears to be an inverse relationship between male and female employment during the period. Figure 3 provides the scatter plots between formal and informal employment for male and female along with a trend line. The slope of the trend line for both genders was negative and the R2 was 0.257 for females and 0.397 for males.

Figure 3: Formal vs Informal Employment

Male



Female



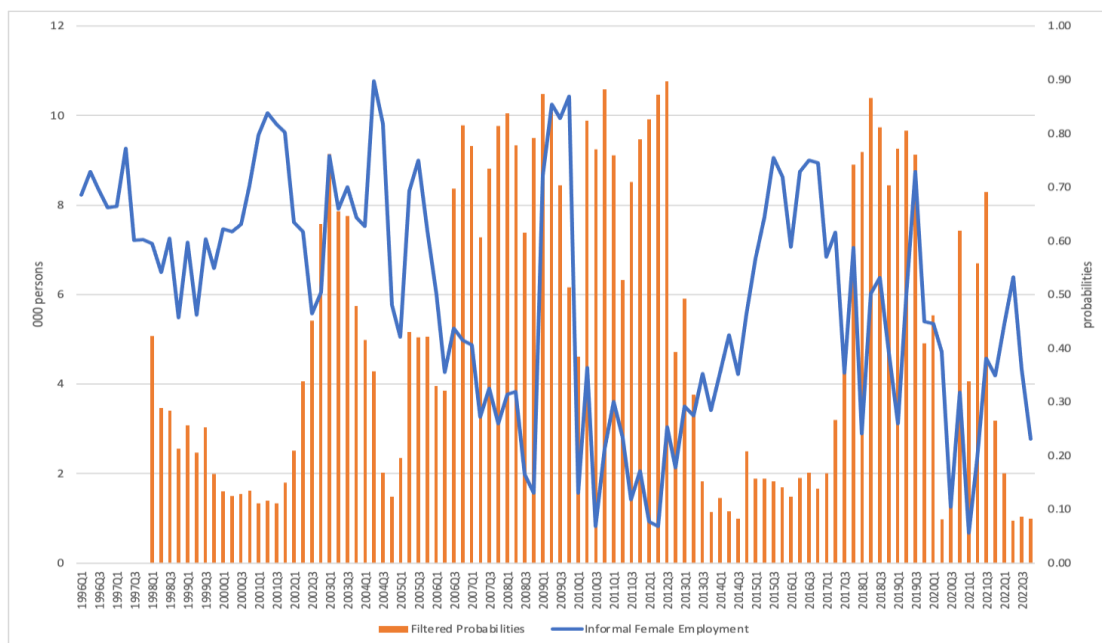
Source: Barbados Statistical Service and Authors' Calculations

The above calculations suggest that there is a relationship between formal and informal employment, even when a relatively simple bivariate analysis is completed. The analysis, however, can not tell us whether the informal sector is acting as a buffer for the formal sector. It also does not account for the effects of third variables that might impact on the bivariate analysis

4 Empirical Results

The MSVAR model provides a reasonable explanation of the cyclical pattern of informal female and informal male employment (Figure 4 and Figure 5). The filtered probabilities identify four periods of particularly high levels of informal female employment (Figure 4): 1998-2001, 2004-2005; 2013-2017; 2020; and, 2022. The first three periods of relatively rapid growth, while the later two periods could be attributed to the COVID-19 pandemic.

Figure 4: Informal Female Employment and Filtered State Probabilities

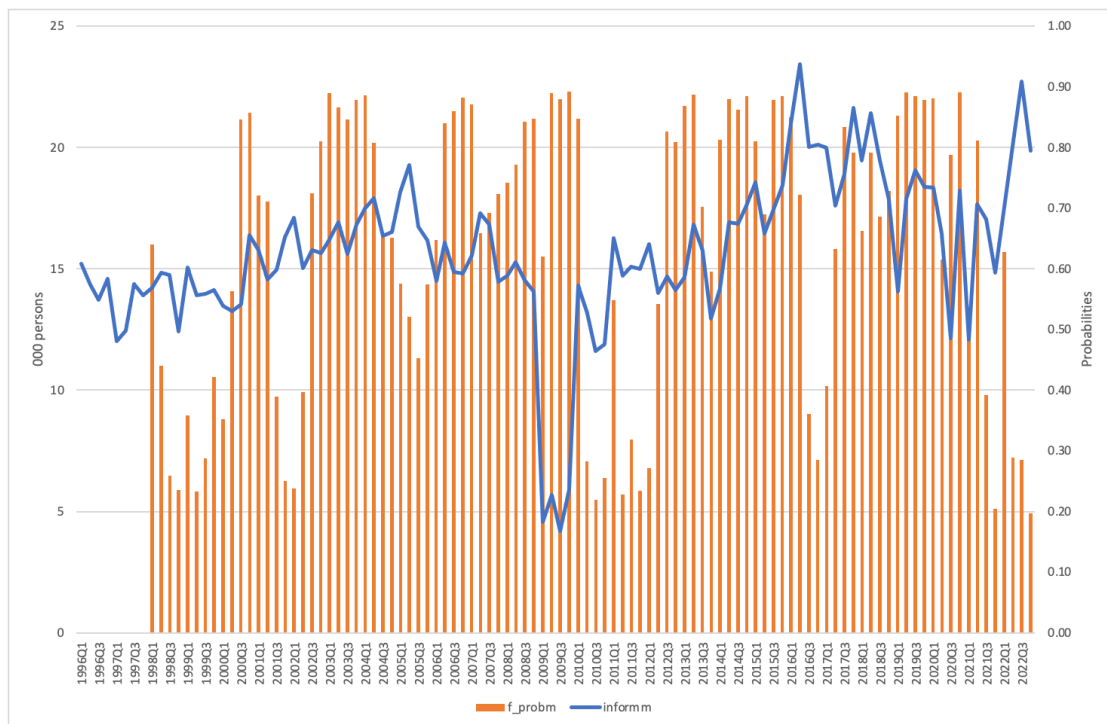


Source: Authors' Calculations

In the case of males, 6 eras were identified of high levels of informal female employment (Figure 4): 1998-2001; 2004; 2013-2017; 2020; and, 2022. These periods were relatively similar to those identified for males which suggests that there might be

some correlation between the periods of high informality for male and female workers. While the informal sectors that provide jobs for males and females might be different, they do seem to offer some opportunities for employment during downturns in the business cycle, particularly in recent years.

Figure 5: Informal Male Employment and Filtered State Probabilities



Source: Authors' Calculations

Table 1 below presents the results of the multivariate MSAR models for each variable. Looking first at the female informal labour equation, formal female employment is inversely related to informal female employment. These results support the hypothesis that the informal economy could provide opportunities for employment during periods of downturns in economic activity and are similar to the findings of Colombo et al. (2016), Colombo et al. (2019), Fiess et al. (2010) and Loayza & Rigolini (2011). Economic growth has a positive and statistically significant impact on informal female employment.

With every 1 percent increase in economic growth, increasing female informal employment by 3 percent. The dummy variable to capture the effects of the COVID-19 pandemic suggests that the pandemic would have reduced informal employment. The dummy variable included to capture the effects of the Global Financial Crisis, however, was statistically insignificant from zero. Given that the COVID-19 pandemic was associated with lockdowns, this might have limited the opportunities for the informal sector to offset the effects of declining formal employment for females and therefore explains the negative coefficient on this dummy variable. The AR dummy is negative and statistically significant and suggests that approximately 64 percent of any shock is corrected in the following period. The regime switching intercepts are both statistically significant but have different signs: in state one the mean change in informal employment is negative while in state two the mean change in formal employment is positive.

The results for male informal labour were somewhat similar. The coefficient on the formal male employment term was negative and statistically significant. This result was similar to the regression for female employment and suggests that the informal sector was acting as a buffer for the formal sector in this labour market. One of the reasons why this might be the case is due to the differences in characteristics of the informal sectors that females and males might find employment. In contrast to the regression for informal female employment, the Global Financial Crisis and the COVID dummies were statistically insignificant in the informal male regression. This suggests that the informal sectors that generate jobs for males might not be highly correlated with either real or financial sector shocks.

Table 1: Results of Multivariate MSAR model

	<i>Dependent Variables</i>		
	Total Informal Labour	Female Informal Labour	Male Informal Labour
Total Formal Labour	2.053 (1.173)*		
Formal Female Labour		-7.881 (1.352)**	
Formal Male Labour			-4.963 (0.419)**
Growth	-0.001 (0.007)	0.029 (0.014)*	0.026 (0.005)**
COVID Dummy	-0.090 (0.081)	-1.091 (0.260)**	-0.077 (0.121)
GFC Dummy	-0.067 (0.063)	0.287 (0.198)	-0.070 (0.122)
AR(4)	-0.462 (0.111)**	-0.641 (0.099)**	-0.424 (0.108)**
Intercept(s1)	-0.114 (0.023)**	-0.227 (0.086)**	-0.080 (0.031)**
Intercept (s2)	0.145 (0.038)**	0.254 (0.069)**	0.136 (0.042)**
<i>Transition Probabilities</i>			
<i>P11</i>	0.871	0.9156	0.893
<i>P12</i>	0.142	0.1125	0.189

The results for total informal employment provide the justification for disaggregating the results between male and female informal employment, as the overall regression does not provide any evidence that the informal sector acts as a buffer for the formal sector. The coefficient on total formal employment was positive and statistically significant, suggesting that total formal and total informal employment are positively correlated. This would suggest that a negative shock to formal employment would also result in a downturn in the informal sector. This overall finding might be due to the different effects of shocks on male and female informal labour markets.

To assess the robustness of the results reported earlier, the authors consider other model specifications to see if the main findings of the results reported earlier change appreciably. One alternative model specification is to allow the coefficient on the formal variable to change with each state. In this specification, the impact of formal employment would be allowed to differ in state 1 relative to state 2. Within this model specification the coefficients on the control variables do not change appreciably so only the state-dependent coefficients are reported (Table 2). The results suggest that for both regressions only one state coefficient is statistically different from zero, supporting the model specification reported earlier that restricted this coefficient across the two states.

Table 2: State Dependent Coefficients Multivariate MSAR model

	<i>Dependent Variables</i>	
	Female Informal Labour	Male Informal Labour
Formal labour		
state 1	-10.520 (1.774)**	-7.359 (0.403)**
state 2	-3.608 (2.515)	0.123 (0.612)

Table 3 provides the results of the regression allowing the variance to switch between the two states. The results are again quite similar to those reported earlier. The variables of interest, the coefficients on the formal employment variable are quite similar as well as the coefficients on the control variables.

Table 3: Results of Multivariate MSAR Model With Time-Varying Variance

<i>Dependent Variables</i>		
	Female Informal Labour	Male Informal Labour
Formal Female Labour	-9.315 (0.933)**	
Formal Male Labour		-5.005 (0.447)**
Growth	0.020 (0.016)	0.026 (0.005)**
COVID Dummy	-0.956 (0.294)**	-0.227 (0.134)
GFC Dummy	-0.078 (0.185)	-0.082 (0.084)
AR(4)	-0.567 (0.097)**	-0.403 (0.111)**
Intercept(s1)	0.001 (0.061)	-0.086 (0.040)**
Intercept (s2)	0.315 (0.041)**	0.125 (0.048)**
<i>Transition Probabilities</i>		
<i>P11</i>	0.949	0.883
<i>P21</i>	0.136	0.152

5 Discussion

The informal sector is a large and important part of the economy in many countries, providing employment for millions of people. The informal sector is often seen as a way for people to escape poverty and earn a living, but it also has a number of disadvantages. One of the main benefits of the informal sector is that it provides employment opportunities for people who would otherwise be unemployed. The informal sector is often more flexible than the formal sector, and it can be easier to start a business in the informal sector. This means that it can be a good option for people who have few skills or education, or who are unable to find work in the formal sector.

The informal sector can also be a source of innovation and entrepreneurship. In many countries, the informal sector is where new ideas and businesses are first developed. This is because the informal sector is often less regulated than the formal sector, and it can be easier to experiment and take risks. However, the informal sector also has a number of disadvantages. One of the biggest problems is that it is often unregulated, which means that workers are not protected by labour laws. This can lead to low wages, poor working conditions, and exposure to hazardous materials. Another problem with the informal sector is that it is often difficult to track and measure. This makes it difficult to assess the size of the informal sector, and to track its impact on the economy.

Overall, the informal sector is a complex issue with both positive and negative aspects. The predominant policy position towards the informal economy has sought to control, deter and eradicate the phenomenon but it is important to weigh the benefits and drawbacks of the informal sector when developing policies to address it.

The results suggest that informal workers behave differently during a shock which by extension suggests that the policy approach should be context specific for each group. The usual approach of extending the social protection programmes or legalisation of the informal worker underestimates social, cultural and contextual factors that often mould both people's attitude towards economic activity and the way in which they relate to the law and the state (Selpuveda & Syrett, 2007). What is needed therefore, is for a more integrated approach to the formalisation. Integrated approaches may take two forms, explicit or implicit. Formalisation strategies may emerge explicitly, where national development and growth strategies, plans, employment policies, poverty reduction strategies and budgets, commit to transition towards formality. Alternatively, formalisation might occur implicitly due to the impact of policies even if policies or measures proposed do not have formalisation as an explicit goal. For instance, industrialisation policies might generate economic transformation that leads to higher levels of formalisation but does not in of itself target formalisation of the informal workers directly. Whether explicit or implicit, formalisation is a process that requires policy integration.

6 Conclusions

The paper discusses the role of informal labour in Barbados. It finds that informal labour can contribute to productivity and economic growth, and that it serves as a protective buffer during economic downturns. The paper concludes that efforts should be made to enact policies to make it easier for informal workers to contribute to the social security system and formalise. Informal labour is defined as work that is not covered by labour

laws or social security schemes. It is often characterised by low wages, poor working conditions, and lack of job security. In Barbados, informal labour accounts for about 40% of the workforce.

As highlighted in the introduction, the accessible entry points for such firms result in a substantial share of economic activity and employment. Our empirical findings indicate that the presence of informal labour in Barbados could contribute to productivity and economic growth. Furthermore, we observe that informal labour serves as a protective buffer during economic downturns, leading us to perceive it as a supportive force for development rather than a hindrance.

The paper finds that informal labour can contribute to productivity and economic growth in a number of ways. First, it can provide a source of employment for people who would otherwise be unemployed. Second, it can help to create new businesses and industries. Third, it can provide a source of income for people who are unable to find formal employment. For example, informal workers may be able to start their own businesses with little capital, and they may be more willing to take risks than formal workers. This can lead to innovation and new job creation.

The paper also finds that informal labour can serve as a protective buffer during economic downturns. During a recession, formal businesses may lay off workers, but informal businesses are often able to continue operating. This is because informal businesses are often less reliant on formal financial institutions and can more easily adapt to changing economic conditions. For example, informal workers may be able to reduce their costs by working from home or by using less expensive materials. They may also be able to find new customers or markets more easily than formal businesses.

The paper concludes that efforts should be made to enact more integrated policies to make it easier for informal workers to formalise. An integrated approach can address multiple components and foster collaboration among various institutions. These strategies can address factors or catalysts for informality on a broad scale, encompassing macro-level initiatives. Alternatively, they can be targeted micro-level endeavours, such as programs designed for specific groups of workers or enterprises within particular sectors. While expanding social protection programs is important, a comprehensive approach to formalising informal workers should also be pursued to address the structural issues that drive informality and create an environment where transitioning to the formal sector is both feasible and desirable for individuals and businesses.

Overall, the paper argues that informal labour can play a positive role in the economy. However, it is important to ensure that informal workers are protected and that they have access to the same benefits as formal workers. Given the significant labour surpluses in small islands, the informal labour market plays help to ease the strain on formal job markets, benefiting the overall labour ecosystem. Therefore, embarking on structural reforms to reduce the size of the informal economy may actually be detrimental to the country's growth prospects. Rather efforts should be made to enact policies to make it easier for these workers to contribute to the economy and move policy away from the parasitic purview to recognising the symbiotic nature of the sector in facilitating economic expansion.

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